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Revision of the Silurian and Early Devonian Chonetoidean Brachiopods of Southeastern Australia

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ABSTRACT. Thirty-eight species of ostensibly chonetoid brachiopods (some under open nomenclature) have been described from the Silurian and Lower Devonian rocks of southeastern Australia, although most are neither widely distributed nor abundant. Descriptions of many have been based on inadequate material, and in one significant case (*Johnsonetes australis*) the original material is lost, necessitating selection of a neotype to resolve formally the identity of that species in comparison with the similar species *J. culleni*. In this systematic revision the known species are redescribed and where possible their generic positions and possible synonymy determined; three are rejected from the Chonetoidea.

Silurian taxa include *Strophochonetes melbournensis, S. kemezysi* n.sp. and "*Protochonetes*" cf. *minimus*. Early Devonian faunas are much more diverse. Lochkovian species are *S.? savagei* n.sp., *S.? psiloplia, "S." cresswelli, Parachonetes robustus*, and the poorly known *"Chonetes" ruddockensis. "Strophochonetes" cresswelli* and *P. robustus* are also found in the Pragian, along with *Asymmetrochonetes? planata, Parachonetes baragwanathi, P.? bowieae, P.? suavis, Septachonetes micrus, "Chonetes" taggertyensis* and *"Chonetes" foedus*. The youngest species in the region are Emsian: *Johnsonetes australis, J. culleni, J. latus, Septachonetes melanus, Parachonetes buchanensis, P. spooneri, P. konincki* and *P. flemingi*. No species is currently known to be sufficiently widely distributed geographically and sufficiently restricted stratigraphically to be of clear biostratigraphic use.

Several former species are junior synonyms. *Strophochonetes melbournensis* includes *Chonetes infantilis*, and *Johnsonetes australis* includes *Chonetes teicherti. Parachonetes robustus*, the name-bearer for Gill's *"robustus gens"*, certainly includes both *Chonetes killarensis* and *C. productoida*. It is likely that the two other species of this group, *P. baragwanathi* and *P. buchanensis*, are also synonymous but, for lack of appropriate specimens, this cannot be conclusively established.

The Cambrian *Chonetes concinna*, subsequently (and wrongly) referred to *Eoorthis*, is refigured and confirmed as not being a chonetoidean. *Chonetes gaskini* is shown to be the ventral valve of a spiriferid, and *Chonetes bipartita* has already been assigned to the sowerbyelloid *Plectodonta*.

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The superfamily Chonetoidea is a group of distinctive Palaeozoic spiny brachiopods, in which the spines are restricted to the posterior margin of only one valve. Its representatives are distributed worldwide, and have been shown to be useful environmental and palaeobiogeographic indicators at least in the Silurian and Devonian (Racheboeuf, 1990). Although not a major component of the brachiopod faunas described from the Silurian and Devonian of

southeastern Australia, they are common and distinctive enough to have been recognised as long ago as 1876, when McCoy described *Chonetes australis* from the Devonian of Victoria. About the same time, De Koninck (1877) identified Australian material from several localities, sent to him by W. B. Clarke, as identical with European species. The specimens from Quidong (near Delegate in far southeastern New South Wales) De Koninck unequivocally identified as *Chonetes striatella* (now *Protochonetes*). They could be identical with *Protochonetes?* sp. indet. described from the Silurian of Canberra by Strusz (1982). The specimens from "a dark grey limestone in the Yass District" identified by De Koninck as *Chonetes hardrensis* are less easy to relate to the species dealt with herein, but could be the Silurian *Strophochonetes kemezysi* n.sp. Unfortunately De Koninck figured none of the specimens, which were subsequently lost in the Garden Palace fire of 1882.

Thirty-eight species ascribed to the superfamily have been described from the southeastern Australian Silurian and Devonian, many in a series of papers by E.D. Gill (1942–1951). However, most of the taxa were based on less than adequate material, and have not until now been assessed in the light of modern understanding of the superfamily. The relationships between some long-standing very similar species have been unclear because of this, and more recently collected specimens have often proved difficult to assign to named species. This study is an attempt to remedy that situation. Opportunity is taken to establish as clearly as possible the stratigraphic and geographic distribution of the species recognised, and to amplify morphological descriptions where appropriate. A synoptic list of the species recognised here is given just before the Systematics section. A map of southeastern Australia (Fig. 1) shows locations referred to in this paper.

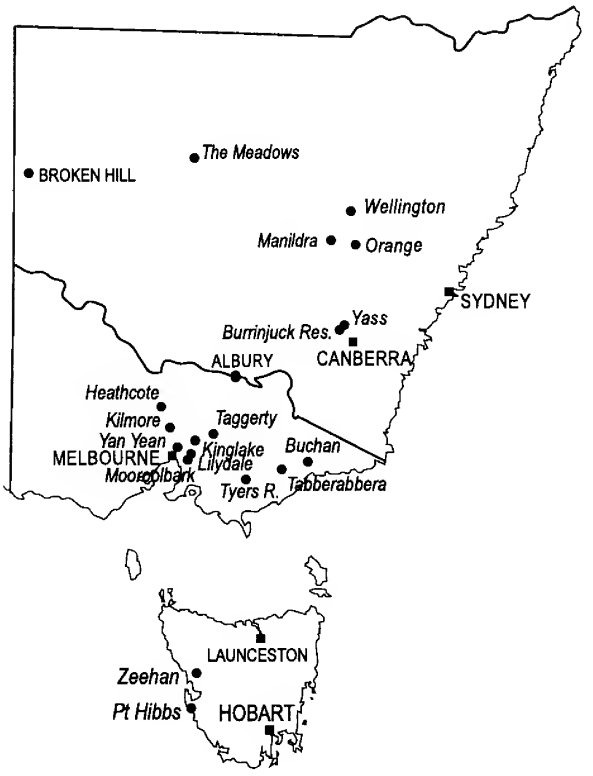

Figure 1. Map of southeastern Australia providing a key to the location of the chonetoid faunas described in this paper. In the case of geographically close central Victorian localities, the nearest significant town (as noted in the text) is shown.

Materials and methods

Materials. Most of the material used in this study is housed by the Museum of Victoria (Melbourne) and the Australian Museum (Sydney). Published specimens formerly in the collections of the Geological Survey of Victoria, the Universities of Melbourne and Sydney, and University of New England (Armidale) have been transferred to the two State museums. Some specimens are also held by the Geological Survey of New South Wales in Sydney, and the Australian Geological Survey Organisation and Australian National University in Canberra. Additional unpublished material is held by both Canberra organisations and the Museum of Victoria. Registered numbers for fossils now or once held by these various institutions are prefixed by the following acronyms:

AM	Australian Museum.
ANU	Geology Department, Australian National University.
CPC	Commonwealth Palaeontological Collection, Australian Geological Survey Organisation.
GSV	Geological Survey of Victoria.
MMF	Palaeontological Collection, New South Wales Department of Mineral Resources (Geological Survey of New South Wales).
MUGD	Department of Geology, University of Melbourne.
NMV	Museum of Victoria.
SU	Geology Department, University of Sydney.
UNE	Department of Geology & Geography, University of New England.

Terminology. Morphological terminology and definitions follow those in Racheboeuf (1998), which correspond to those used in the revised Brachiopoda volumes of the Treatise on Invertebrate Paleontology (Williams *et al.*, 1997 *et seq.*). When referring to hinge spines, position, symmetry and ordering are as in Racheboeuf (1981). Spines are numbered 1, 2, 3... to the right of the ventral umbo, corresponding to 1', 2', 3'... to the left, as viewed with ventral valve uppermost and beak towards top.

Unless otherwise specified, the divergence of bilaterally symmetrical structures, such as anderidia, is quoted as the angle included anteriorly between the structures, not their divergence from the centre-line of the shell. Where possible, the density of radial ribs is specified as the number in a 5 mm sector at a radius of 5 mm.

The following abbreviations (linear measurements in millimetres) are used:

Ls maximum length of shell excluding hinge spines; coincident with length of ventral valve.
Ld length of dorsal valve.
Ws maximum width of shell, measured normal to plane of symmetry.
Wh width of shell at hinge line.
Ds depth (or thickness) of shell (= depth of ventral valve in most chonetoids) measured normal to length and width.
α the angle included between the hinge line and the proximal part of a hinge spine, measured abaxially.

All grid references and map coordinates are based on the Australian Geodetic Datum of 1966. In the descriptive part of this paper, new illustrations are generally not provided for species where no new and informative material is available and the original illustrations are sufficient.

Results

All but three of the 28 chonetoidean species here recognised can be assigned with varying degrees of confidence to seven genera in two families, Strophochonetidae and Anopliidae, of which the first dominates. Only two species of one endemic genus, *Septachonetes*, are anopliids. Three named species cannot be assigned with any confidence even at the family level.

In Victoria, taxa come from both the Melbourne Trough, and the Early Devonian sequences of East Gippsland (Buchan, Tabberabbera, Tyers). Of two Tasmanian forms, one is probably the same as a species from Buchan, and the other is unusable. In New South Wales most of the species are from the Canberra-Yass Shelf, with a scatter of records from the Molong High farther north, or the ill-exposed Cobar Trough in the west. Unfortunately, in nearly all cases the species are based on specimens from at most only a handful of localities, so biostratigraphic utility is difficult to assess. In the case of taxa from the Emsian of the Taemas region in New South Wales, stratigraphic distribution does seem to be consistent within the basin, but the area concerned is small. The Silurian Melbourne Trough species *Strophochonetes melbournensis* (Chapman, 1903) is more widely distributed than other taxa, but seems also to have a rather extended stratigraphic range and so is of limited biostratigraphic use. An extended range is also shown by *Parachonetes buchanensis* (Gill, 1951) in the geographically restricted Emsian sequence at Buchan.

One other consequence of this rather scattered distribution of species both geographically and stratigraphically is the difficulty in establishing phylogenetic lineages. It is possible that the Wenlock-Ludlow Victorian species *Strophochonetes melbournensis* (Chapman, 1903) gave rise to the Ludlow-Přídolí species *S. kemezysi* n.sp. from Yass. A group of species centred around *Parachonetes baragwanathi* (Gill, 1949) was thought by Gill to be a phylogenetic plexus (the *"robustus gens"* of Gill, 1951), but most of these species are incompletely known and most (if not all) will probably eventually be shown to be junior synonyms of *P. robustus* (Chapman, 1903). If that is the case, the range of this taxon will be quite long: mid-Lochkovian to Emsian-most of the Early Devonian. Its relationship to other Australian species of *Parachonetes* is not clear.

Finally, this study retains as distinct the very similar early to mid-Emsian species *Johnsonetes australis* (McCoy, 1876) from Buchan and *J. culleni* (Dun, 1904) from Taemas. Synonymy of these two species, as proposed by Brock & Talent (1993), could only be established if intermediate forms revealing greater structural variability were to be found. Variability to the extent needed to establish that synonymy would cast doubt on some of the criteria currently used to distinguish a significant number of chonetoid species.

The following synoptic list is of the species recognised herein, arranged systematically, with a summary of their ages and palaeogeographic distribution (the latter abbreviated as: WTT, Western Tasmania Terrane; MT, Melbourne Trough; G, Gippsland "basins"; CYS, Canberra-Yass Shelf; MH, Molong High; CT, Cobar Trough).

Strophochonetes melbournensis (Chapman, 1903); Wenlock to Ludlow, MT.
Strophochonetes kemezysi n.sp.; Late Ludlow to Přídolí, CYS.
Strophochonetes sp. Sherwin, 1995; Lochkovian, CT.
Strophochonetes? savagei n.sp.; Early Lochkovian, MH.
Strophochonetes? psiloplia (Gill, 1945); Lochkovian, MT.
"Strophochonetes" cresswelli (Chapman, 1903); Lochkovian to Pragian, MT.
Johnsonetes australis (McCoy, 1876); Early to middle Emsian, G.
Johnsonetes culleni (Dun, 1904); Early Emsian, CYS.
Johnsonetes latus (Chatterton, 1973); Middle Emsian, CYS.
Johnsonetes? sp.; Early Pragian, MH.
Asymmetrochonetes? planata Lenz & Johnson, 1985; Early Pragian, MH.
"Protochonetes" sp. cf. *minimus* (J. de C. Sowerby, 1839); Late Wenlock to Early Ludlow, CYS.
Protochonetes? sp. indet. Strusz, 1982; Late Wenlock, CYS.
Parachonetes baragwanathi (Gill, 1949); Early to middle Pragian, MT, G.
Parachonetes robustus (Chapman, 1903); Middle Lochkovian to middle Pragian, MT.
Parachonetes? sp. cf. *robustus* (Chapman, 1903); Late Lochkovian, MT.
Parachonetes buchanensis (Gill, 1951); Emsian, G.
Parachonetes? sp. cf. *buchanensis* (Gill, 1951); Early Pragian, WTT.
Parachonetes koninckí Chatterton, 1973; Middle Emsian, CYS.
Parachonetes flemingi Chatterton, 1973; Middle Emsian, CYS.
Parachonetes? bowieae (Gill, 1945); Early Pragian, MT.
Parachonetes? suavis (Talent, 1963); Early to middle Pragian, G.
Parachonetes? spooneri (Talent, 1956); Early Emsian, G.
Parachonetes? sp.; Early Pragian, MH.
Septachonetes melanus Chatterton, 1973; Middle Emsian, CYS.
Septachonetes micrus (Gill, 1951); Pragian, MT.
"Chonetes" taggertyensis (Gill, 1945); Early to middle Pragian, G.
"Chonetes" ruddockensis Gill, 1945; Middle to late Lochkovian, MT.
"Chonetes" foedus Talent, 1963; Early to middle Pragian, G.

Systematics

Chonetoidea Bronn, 1862

Strophochonetidae Muir-Wood, 1962

Strophochonetinae Muir-Wood, 1962

Strophochonetes Muir-Wood, 1962

Type species. *Chonetes cingulatus* Lindström, 1861, 374. Wenlock, Gotland.

Diagnosis. "Shell small, plano- to moderately concavo-convex; well-developed median enlarged costa; long and symmetrically arranged high-angled spines varying from intraverse cyrtomorph proximally to orthomorph vertical distally; cardinal process strongly bilobed internally, anteriorly bounded by a cardinal process pit; no median septum; anderidia long and narrow, anteriorly divergent at 60° and isolated on the valve floor; inner socket ridges short and thin, as two rounded ridges almost parallel to hinge." (Racheboeuf, 1998: 37).

Discussion. It is unfortunate that Muir-Wood (1962) based her genus on a species which had not been effectively redescribed and figured since its erection by Lindström (1861), and which is still not well known. She offered a very brief and incomplete description, and figured only exteriors of both valves. Johnson (1970, pl. 30, figs. 1–5) figured two dorsal interiors and three ventral exteriors from Fröjel, Gotland, and made only brief comments on dorsal internal morphology. Bassett (1977: 160–161) merely reiterated Johnson's limited observations, and Racheboeuf (1981: 36–37, pl. 3, figs. 1–3) again figured only externals supported by a brief description. The ventral interior is thus still little known, as is variability overall. As more genera are erected on the basis of species previously included in *Strophochonetes*, in the absence of a revision of the type species the concept of what still constitutes *Strophochonetes* has become less clear.

The original generic diagnosis can be rewritten in the light of changes in terminology as: Shell small, thin, of low convexity, hinge at or close to maximum width. Finely capillate, may be smooth umbonally, ventral median capilla enlarged; increase by intercalation and bifurcation; growth lines often prominent. Hinge spines sparse, fine, long, normal to hinge. Ventral median septum short, enlarged posteriorly; teeth massive, wide, transversely striated; muscle field obscure. Cardinal process bilobate, the lobes posteriorly grooved, fused with cardinal crests; dorsal median septum short or absent, cardinal process pit often absent; anderidia prominent, diverging at about 60°, sometimes curved; sockets small, outer socket ridges extending along cardinal margin.

Johnson (p. 1023 in Boucot & Gauri, 1966) confirmed the variability in the dorsal median septum, stating that it was absent in *S. cingulatus*—certainly the case in the dorsal interiors he figured in 1970. In differentiating *Strophochonetes* from her superficially similar new genus *Protochonetes*, Muir-Wood (1962) quoted smaller size, finer ornament including an enlarged median capilla, fewer but longer spines at a steep angle to the hinge, a narrower, less prominent ventral median septum which does not develop a median furrow, a shorter dorsal median septum (often absent), and smaller dental sockets. Muir-Wood (1962: 32) also specified that strophochonetines have no cardinal process pit, despite allowing for its occasional presence in her diagnosis of *Strophochonetes*.

Boucot & Harper (1968: 148–149) repeated Muir-Wood's differentiation between *Strophochonetes* and *Protochonetes*, but went on to note the variability shown by the North American *P. novascoticus* (Hall, 1860), concluding that only the angle of the hinge spines appeared to be a reliable difference. This conclusion depended on a study by Harper (1973); however from Harper's description and figures of that species it is clear that there is no single enlarged median ventral capilla but at most a coarsening of the capillae medially, and that the dorsal median septum is long and well developed. That a medial furrow on the ventral median septum may not always be present in *Protochonetes* does not fully negate the taxonomic usefulness of its consistent absence in *Strophochonetes*, and so there is no significant change from the differences set out by Muir-Wood (1962).

Bassett & Cocks (1974: 21) separated *Strophochonetes* and *Protochonetes*, at least in the Silurian, especially on the presence of an enlarged ventral median capilla in the former, and consistently bifurcating costellae in the latter. Racheboeuf (1976: 47–49) further discussed the differences between the two genera, and his conclusions (summarised below) were followed by Bassett (1977: 160), who placed most emphasis on internal characters in distinguishing the two genera, and also commented on the considerably greater variability in diagnostic features in Silurian species as opposed to Early Devonian ones (by which time the genera were clearly distinct). Racheboeuf's tabulated differentiation shows *Strophochonetes* (*sensu stricto*) differing from *Protochonetes* in the orientation of the hinge spines ($\alpha = 90°$ as opposed to 40–70°), posteriorly thickened ventral median septum never bifid, anderidia more divergent, inner socket ridges not necessarily straight, dental sockets small, and myophore sometimes quadrilobed. Bassett (1977) also noted that in *Strophochonetes*, if a dorsal median septum is developed it is short and separate from the cardinal process. This could be construed as indicating the presence of a cardinal process pit, but it is doubtful that the pit is ever truly prominent in either genus.

Racheboeuf (1981: 40–41) characterised *Strophochonetes* as a group of primitive Chonetacea whose external morphology and cardinalia resemble those of the type species. He modified Muir-Wood's definition to some extent:

—Hinge spines are disposed symmetrically to either side of the beak. The spines, basally oblique, curve progressively towards the plane of symmetry of the shell until they are parallel.
—The dorsal median septum is absent.
—The anderidia are long, narrow, and do not fuse posteriorly with the inner socket ridges.
—The inner socket ridges are short and narrow.
—No mention was made of the enlarged median ventral capilla or the lack of a cardinal process pit in his diagnosis.

Racheboeuf & Lespérance (1995: 18) provided the formal diagnosis used by Racheboeuf (1998), and quoted above. This differs from Muir-Wood's original definition in specifying the presence of a cardinal process pit, and not allowing the possibility of a dorsal median septum. The only two illustrated dorsal interiors (Johnson, 1970, pl. 30, figs. 1–2) are internal moulds; in one there is clearly no sign of a cardinal process pit, but the other shows a small low protuberance which could be evidence of a weak pit.

From the above, it is clear that until the external and internal variability of *S. cingulatus* is established, and a study made of a wide variety of related Silurian species in the light of that variability, assignment of species (especially Silurian species) to the genera grouped around *Strophochonetes* and *Protochonetes* cannot be achieved with any great confidence.

Strophochonetes melbournensis (Chapman, 1903)

Figs. 2, 3

Chonetes melbournensis Chapman, 1903: 74–76, pl. XI, fig. 2 only.
Chonetes (Chonetes) melbournensis.–Gill, 1945: 132–133.
Chonetes infantilis Öpik, 1953: 15, pl. III, figs. 19–22.

Type material. Chapman (1903) did not designate a holotype from amongst his listed specimens. Unfortunately many of these, including one of his two figured specimens, are not chonetoideans. I here select a specimen re-figured by Gill (1945) as lectotype. LECTOTYPE. NMV P1419 (Fig. 2a), a ventral external mould from a sewerage tunnel in Flinders Street, Melbourne, near the old fish market, figured Chapman (1903, pl. XI, fig. 2), and described (erroneously) as a dorsal valve by Gill (1945); Melbourne Formation, Ludlow. PARALECTOTYPES *conspecific with lectotype*. NMV P615, 616, 619, 639, 640, 641A,B, 642A, 643A,B from the Swanston Street sewerage tunnel near Collins Street, Melbourne; NMV P623, 625–27 from the same tunnel near the cathedral; NMV P630 + counterpart 638, 631–33, 637A,B from the sewerage tunnel in Domain Road, South Yarra.

Type material of *Chonetes infantilis* Öpik. HOLOTYPE CPC 661, PARATYPES CPC 662, 663. Locality 44, Parish of Heathcote (see Talent, 1965).

Other assigned material. NMV P874 from GSV locality Bb18 (= NMV PL380, Broadhursts Creek, Wandong-Kilmore East, about 1 km above its confluence with Dry Creek; locality X51 of Williams, 1964), noted by Chapman as a specimen initially identified as a chonetid by McCoy; NMV P30878 from the Domain Road sewerage tunnel; NMV P33097–98 from the Yan Yean Formation at Yan Yean; P52815 collected F. Spry, 1909 from South Yarra (Melbourne); NMV P79767 collected F. Spry, 1922, from an excavation in Melbourne; NMV P142028 from Alexandria Avenue, South Yarra, between the Punt Road bridge and the railway line.

Syntypes rejected from *Strophochonetes melbournensis*. NMV P617 + counterpart 621, 618, 620, 622, 624, 642B from the Swanston Street sewerage tunnel; NMV P634A + counterpart 636, 634B, 635 from the Domain Road sewerage tunnel. These are all probably referable to the sowerbyellid *Jonesea thomasi* (Talent, 1965).

Stratigraphic distribution. Melbourne Formation (including very dark grey and dark olive-green siltstones of the *Jonesea thomasi* Zone); *Illaenus* Band, Wapentake Formation; Yan Yean Formation (including in part the Kilmore Siltstone of VandenBerg in Douglas & Ferguson, 1988); all in the Melbourne Trough, Victoria.

Age. Early Wenlock to Ludlow, Silurian. The *Illaenus* Band was thought by Öpik (1953) to be middle Llandovery, but is now (Strusz, 1996; Rickards & Sandford, 1998) considered more likely to be early Wenlock.

Diagnosis. Small, weakly concavo-convex, subquadrate *Strophochonetes* with up to 5 pairs of gently intraverse-cyrtomorph hinge spines, and finely capillate ornament with median capilla on ventral valve usually strongly enlarged. Valve floors heavily papillose, ventral muscle field distinct, anderidia short and diverging at about 80°.

Description. Shell small, plano-convex to gently concavo-convex, ventral valve of low convexity (D/L about 0.18). Some ventral valves with broad and very shallow sulcus anteriorly. Outline subquadrate, lateral margins gently sigmoid, with shallow re-entrants in front of small rounded ears; hinge width usually equal to width near midlength, sometimes slightly less. Maximum observed width 12.6 mm, length 7.5 mm; mean Ls/Ws 0.61. Ventral interarea low, apsacline, flat; small apical pseudodeltidium in wide triangular delthyrium; beak very low. Dorsal interarea very low, anacline; possible small apical chilidium; distinct elongate protegular node. Myophore poorly known, probably quadrilobate. Hinge spines fine, relatively long, nearly upright (initial angle with hinge line about 70°), straight to gently cyrtomorph intraverse; up to 5 each side of beak.

Ornament of fine radial capillae, about 27 in 5 mm at 5 mm radius, increase by bifurcation only. Median capilla on ventral valve usually prominent, especially through greater width; enlarged capilla occasionally slightly to one side of plane of symmetry.

Ventral interior with low, narrow median septum, reaching forward to about 25% Ls, and posteriorly widened. Teeth small, widely divergent, barely projecting beyond hinge margin. Muscle field often obscure; where distinct, is flabellate, posterolaterally moderately impressed, and without papillae. Remainder of valve floor, when well preserved, densely papillose; papillae radially arranged beneath capillae, weakest towards cardinal margin and ears. Valve floor posterolateral to muscle field coarsely and less regularly papillose, the papillae generally radially elongate.

Dorsal interior known from only one imperfectly preserved specimen (NMV P639). Cardinal process small, fused to short but strong inner socket ridges which are curved subparallel to hinge margin. Long, low, wide median ridge apparently most pronounced posteriorly and at about midlength. Anderidia short, low, diverging at about 80°. Muscle field obscure. Distal two-thirds of valve floor with numerous small papillae arrayed radially beneath exterior capillae, as in ventral valve.

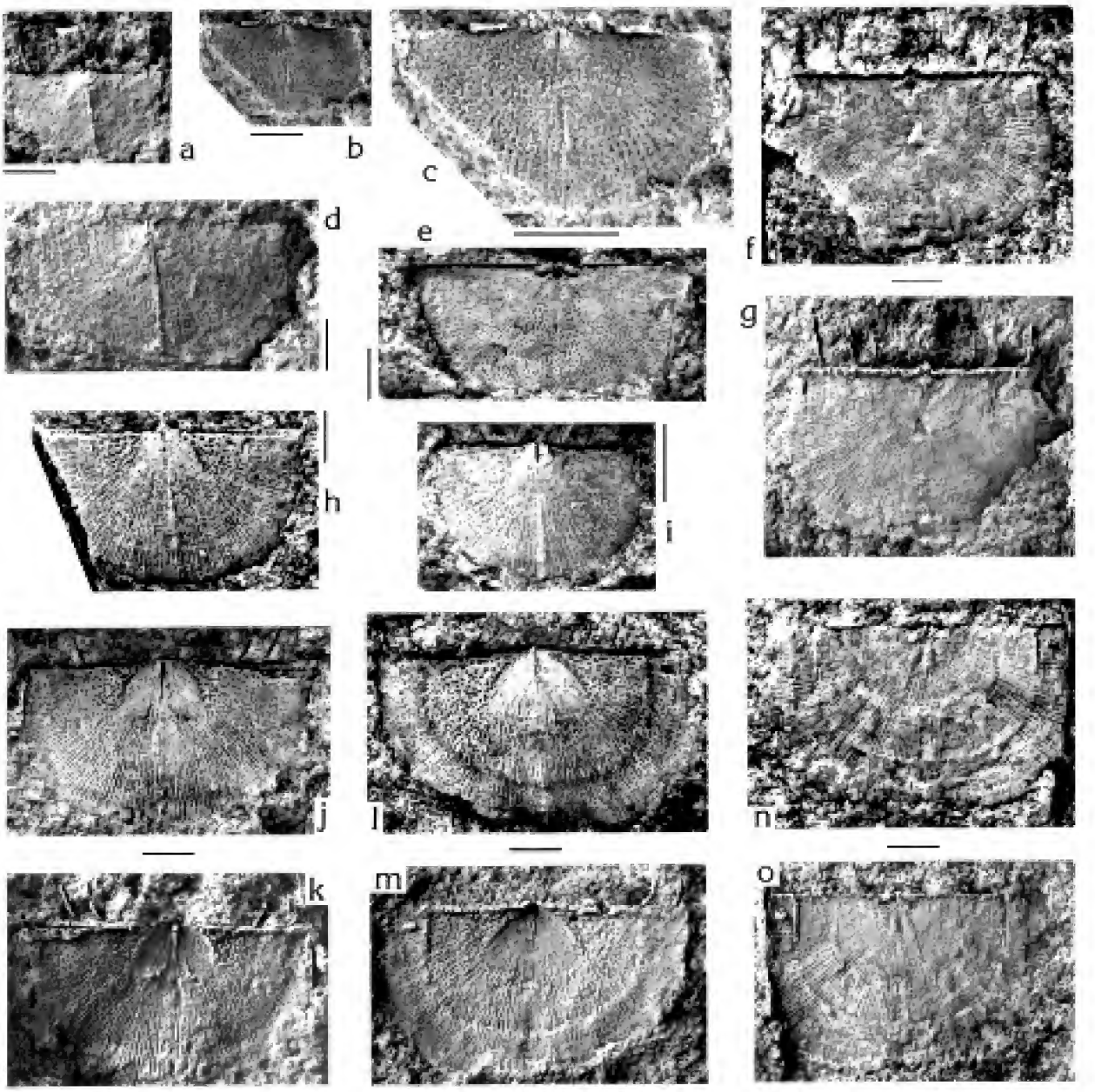

Figure 2. **a–o**: *Strophochonetes melbournensis*; **a**, lectotype NMV P1419, latex from ventral external mould; **b,c**, holotype CPC 661 of *Chonetes infantilis*, ventral internal mould; **d**, paralectotype NMV P638, latex from ventral external mould; **e**, paralectotype NMV P639, dorsal internal mould; **f,g**, paralectotype NMV P640, dorsal external mould (plus hinge spines on ventral valve) and latex replica; **h**, paralectotype NMV P626, ventral internal mould; **i**, paralectotype NMV P625, ventral internal mould; **j,k**, paralectotype NMV P627, ventral internal mould and latex replica; **l,m**, paralectotype NMV P641A, ventral internal mould and latex replica; **n,o**, paralectotype NMV P641B, dorsal external mould and latex replica. Melbourne Formation; Ludlow (Gorstian?). Scale bars 2 mm.

Discussion. With its low convexity, almost universal prominent median ventral capilla, long nearly upright gently cyrtomorph hinge spines, widely divergent anderidia, and dorsal median ridge (not septum), Chapman's species clearly belongs in *Strophochonetes*.

Chonetes infantilis was based on three rather poorly preserved specimens, of which one (paratype CPC 662) is now missing. The holotype (CPC 661, Fig. 2b,c) is a nearly complete ventral internal mould and counterpart fragmentary external mould, with Ls 3.7 mm, Ws 6.0 mm, Wh 5.8 mm, and Ls/Ws 0.62. Ornament is finely costellate with the suggestion of an enlarged median capilla; spines are not preserved, but the now lost CPC 662 had one long, fine, straight, upright spine (Öpik, 1953, pl. III, fig. 19). The holotype shows a short, fine median septum which is slightly expanded posteriorly, and small, widely divergent teeth. The remaining paratype (CPC 663) is an incomplete juvenile dorsal external mould which adds little information. The only distinction I can make between Öpik's form and most specimens of *S. melbournensis* is that the one preserved hinge spine on the lost paratype of the former was straight, not gently cyrtomorph. Given the variability in this feature

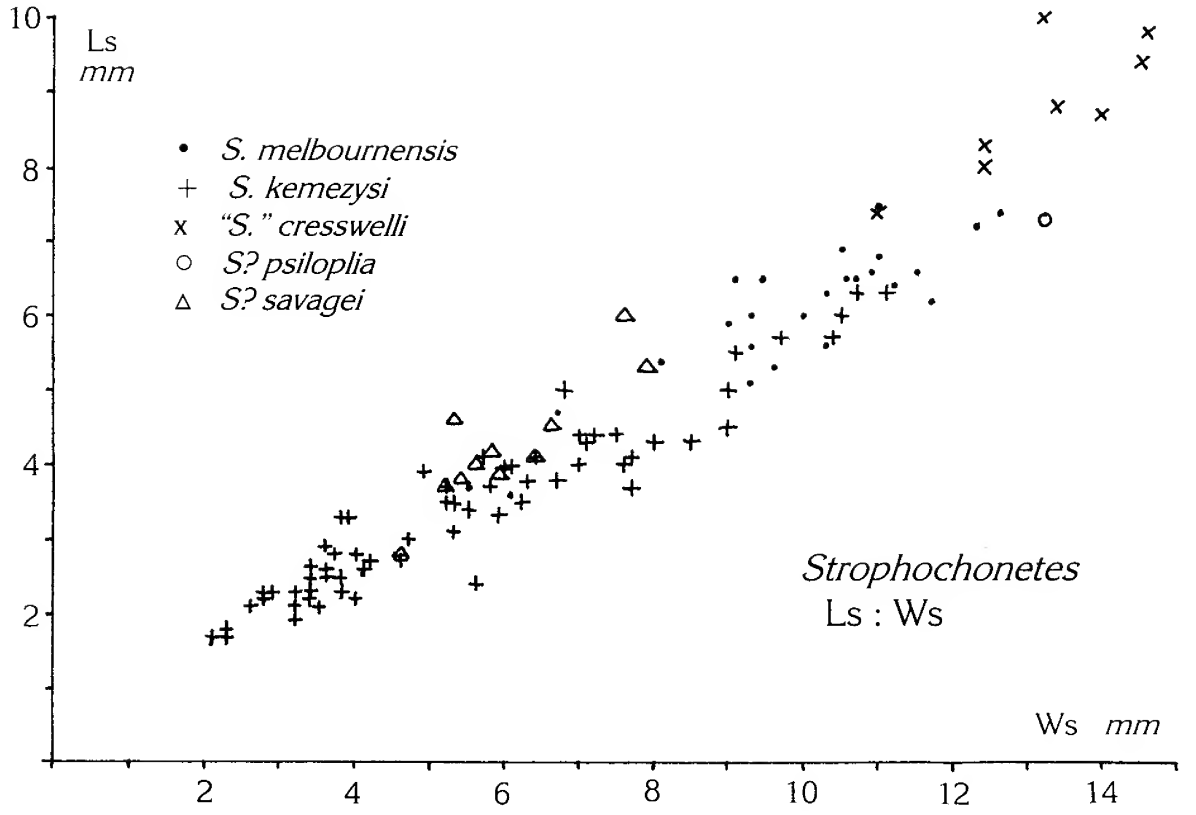

Figure 3. Scatter diagram of length against width for species assigned to *Strophochonetes*.

in the type series of *S. melbournensis*, I do not consider it to be of specific value.

Comparison. In size and convexity *S. melbournensis* is close to the type species, *S. cingulatus* (Lindström, 1861) from the Wenlock of Gotland, and to *S. bassetti* Racheboeuf, 1981 (Wenlock-Ludlow of Aragon), differing from both in its finer ornament, mode of capillar increase, heavily papillose valve floors, distinct ventral muscle field, less obviously bifid cardinal process, and more divergent anderidia. *Strophochonetes cingulatus* has more hinge spines, and longer, finer anderidia, whereas *S. bassetti* has rounded cardinal margins (the hinge line being less than the greatest width), and more robust anderidia. *Strophochonetes piptis* Bassett, 1979 (Wenlock, Gotland), although generally similar, is somewhat larger, with subovate outline and fewer hinge spines; the ventral median capilla is much less prominent. Internally, the papillae are more subdued, the ventral muscle field is longer but less distinct, and the anderidia are stronger and less divergent, separated by a more obvious median ridge. In *S. melbournensis* there is a small apical chilidium; Bassett reported chilidial plates, but his figs. 62C,D show quite clearly that these are cardinal crests (see Brunton *et al.*, 1996: 27); it is not clear if there is a chilidium.

Two Russian species are of similar size: *S. minutus* Alekseyeva, 1967 (Emsian?, eastern Siberia) and *S. paucus* Afanas'yeva, 1996 (Emsian to Eifelian, southeastern Siberia), but the descriptions and illustrations are insufficient for detailed comparison, and in both the dorsal interiors are unknown. Both appear to be more strongly convex than *S. melbournensis*, with coarser ornament.

Strophochonetes kemezysi n.sp.

Figs. 3, 4

Type material. HOLOTYPE ANU 9619, an incomplete dorsal internal mould, and PARATYPES ANU 9617, 9620–26, 9629, 9630, 18737 and 49953 from an outcrop of the Rainbow Hill Member (basal Rosebank Shale) in a cutting on the Lachlan Valley Way just north of the Bowning turnoff, 3.5 km north-northwest of the junction with the Hume Highway northwest of Yass, New South Wales (34°44'55"S 148°50'53"E). Locality KD of Kemežys (1967).

Other material. CPC 35008–12 from AGSO locality GOU4 (collected J. Veevers, 1960): slope above limestone scarp, Hatton's Corner, southwest side of Yass River below Booroo Ponds Creek west of Yass, grid reference FB718421 (34°51'31"S 148°52'44"E); lower Black Bog Shale (Yarwood Siltstone Member?). ANU 9589, 9695, 9699, 15618 from Kemežys' locality KC: gully east of the Lachlan Valley Way 1.8 km north of the bridge over the Sydney-Melbourne railway northwest of Yass, grid reference FB697521 (34°45'33"S 148°51'15"E); Yarwood Siltstone Member. CPC 35013–17 from AGSO locality GOU26: low scarp above Yass rifle range, southwest of the Yass-Good Hope road about 800 m from its junction with the Wee Jasper road southwest of Yass, grid reference FB728379 (34°53'13"S 148°53'26"E); Rainbow Hill Member. ANU 9692, 9693, 9698, 9700, 9716, 49947–52 and CPC 35018–20 from Kemežys' locality KE and AGSO locality GOU46 (collected D. Strusz, 1976): small quarry near gate, east side of Lachlan Valley Way due west of

"Allview" farmhouse about 500 m southeast of the turnoff to Bowning, northwest of Yass, grid reference FB695528 (34°45'13"S 148°51'9"E); Yarwood Siltstone Member. ANU 9694, 9696, and counterparts 9697 and 9701, and CPC 35021 from Kemežys' locality KF and AGSO locality GOU52 (collected D. Strusz 1982): road cutting, east side of Lachlan Valley Way 650 m north of Bowning turnoff northwest of Yass, grid reference FB689537 (34°44'39"S 148°50'44"E); lower Black Bog Shale (below Yarwood Siltstone Member). Counterparts NMV P79775 and 79776 (collected A. Öpik, 1951), from an old road-metal quarry at the Derrengullen Creek crossing by the Hume Highway northwest of Yass, in beds with *Monograptus tomczyki* (*M.* sp. aff. *ultimus* of Packham, 1968—see Sherwin, 1979), Rosebank Shale.

Mitchell Collection, all from the Yass Syncline. AM F25987, locality unknown (lithology and accompanying fauna of fenestellids, other bryozoans, and small proetid trilobites are close to those of the Yarwood Siltstone Member at locality GOU46, see above); AM F27218, Bowning, exact locality and horizon unknown, but the specimen also contains cystoid plates; AM F28552, Bowning, exact locality unknown, but from the Rainbow Hill Member since accompanied by *Palaeocyathus australis* and *Gravicalymene? australis*; AM F107871, Bowning Township (with F28745, holotype of *Stropheodonta striatopunctata* Mitchell which, following Brown [1949] and Cocks & Rong [1989], is probably a synonym of *Plectodonta davidi* Mitchell, and is from Mitchell's "upper trilobite bed", i.e. the Elmside Formation at a level probably of late Přídolí age); AM F28878, Bowning, exact locality and horizon unknown.

Stratigraphic distribution. Black Bog Shale (including Yarwood Siltstone Member), Rosebank Shale (including Rainbow Hill Member), Booroo Ponds Group, and lower Elmside Formation, Barambogie Group, Yass Syncline, southeastern New South Wales.

Age. *Jonesea thomasi* and *Notoparmella plentiensis* Zones, latest Gorstian? or Ludfordian (Ludlow) to Přídolí (at least *parultimus* to *ultimus* Zones and probably younger), Late Silurian (see Garratt & Wright, 1988).

Etymology. Named for my friend Dr Kazys Kemežys, whose collections made while undertaking his PhD research at the Australian National University have been of considerable help in this study.

Diagnosis. Small, moderately to strongly concavo-convex *Strophochonetes* with up to 4 long, fine hinge spines each side of umbo; well-developed protegulal structures; median capilla high but not significantly widened; ventral median septum short, enlarged posteriorly; inner socket ridges robust, straight; anderidia diverge forward at 40–60°; valve floors finely papillate.

Description. Shell small (Ls to 7 mm, Ws to 11 mm), moderately to strongly concavo-convex (Ds/Ls up to 0.48), thin-shelled, so that larger shells often more or less flattened, appearing weakly concavo-convex. Outline semicircular to subovate, maximum width usually at hinge line; cardinal extremities generally flattened, may be extended as small pointed alae. Ls/Ws 0.6–0.8 for small shells, 0.55–0.65 in larger shells. Ventral umbo low, small, projecting slightly posteriorly, formed by distinct protegulum raised slightly above surrounding shell to radius of 0.6–1 mm and ornamented only by growth lines; umbo with marked median furrow which dies out anteriorly. Ventral interarea low, triangular, apsacline, flat; delthyrium wide, with narrow crescentic pseudodeltidium. Dorsal umbo very low, also without capillae, but with strongly marked protegular structures comprising lanceolate median node up to 1 mm long extending from beak, flanked by pair of shorter, strongly divergent ridges detached from both median node and beak, and becoming low and broad anteriorly. Dorsal interarea very low, hypercline (more or less coplanar with ventral interarea). Notothyrium wide, not completely filled by cardinal process; tiny apical chilidium (often obscure). Myophore protrudes slightly above interarea, with marked median furrow separating two weakly bifid lobes; flanked by small but distinct cardinal crests. Hinge spines long, fine, variable from upright to oblique and from orthomorph to weakly inwards geniculate or cyrtomorph, with strongly oblique bases; up to 4 spines each side.

Ornament of low rounded capillae separated by narrower furrows, about 30 in 5 mm at 5 mm radius in larger shells. Capillae faint at their origin at margin of protegulum, becoming more prominent distally. Ventral median capilla mostly raised slightly above the others, but seldom widened significantly. Capillar increase on both valves usually by both intercalation and bifurcation.

Ventral interior with short, narrow median septum, extending from beak to about 20% of valve length, sometimes continued further forward as faint myophragm. Septum raised and widened posteriorly, where top may be flattened or even bifid. Teeth small, unsupported, more or less parallel to hinge. Muscle field mostly slightly to moderately impressed posteriorly, flabellate; posterolateral margins sometimes marked by fine low ridges. Valve floor weakly to moderately impressed by external ornament, with low, fine papillae radially aligned below intercapillar furrows. A few moderately coarser papillae can occur near hinge line to either side of muscle field. Cardinal extremities generally smooth.

Dorsal interior with raised, proximally bifid cardinal process continuous with robust, straight inner socket ridges diverging from hinge line at c. 30°, and often raised on broad ridges. Marked furrows (corresponding to lateral protegulal nodes on umbo) separate inner socket ridges from similarly raised anderidia, which are mostly slightly separate from base of cardinal process, and diverge forward at 40–60°, extending to c. ⅓ valve length. Weak median ridge extends forward from between ends of anderidia to c. ⅔ valve length. Usually small shallow cardinal process pit in front of cardinal process. Valve floor beyond anderidia and socket ridges as in ventral valve. Muscle field obscure.

Comparison. *Strophochonetes kemezysi* is very close to *S. melbournensis*; the only difference in size and proportions is that larger shells are relatively a little wider, and *S. melbournensis* is consistently only moderately concavo-convex (Ds/Ls <0.2). Ds/Ls is far more variable in specimens of *S. kemezysi*, even at the one locality, but this is likely to be largely a result of distortion after burial—many of the flatter specimens show signs of this, such as cracking or crumpling of the thin shell—so the shell probably was more strongly concavo-convex. There is no sign of the shallow ventral sulcus seen anteriorly in some *S. melbournensis*, in which capillar increase is only by

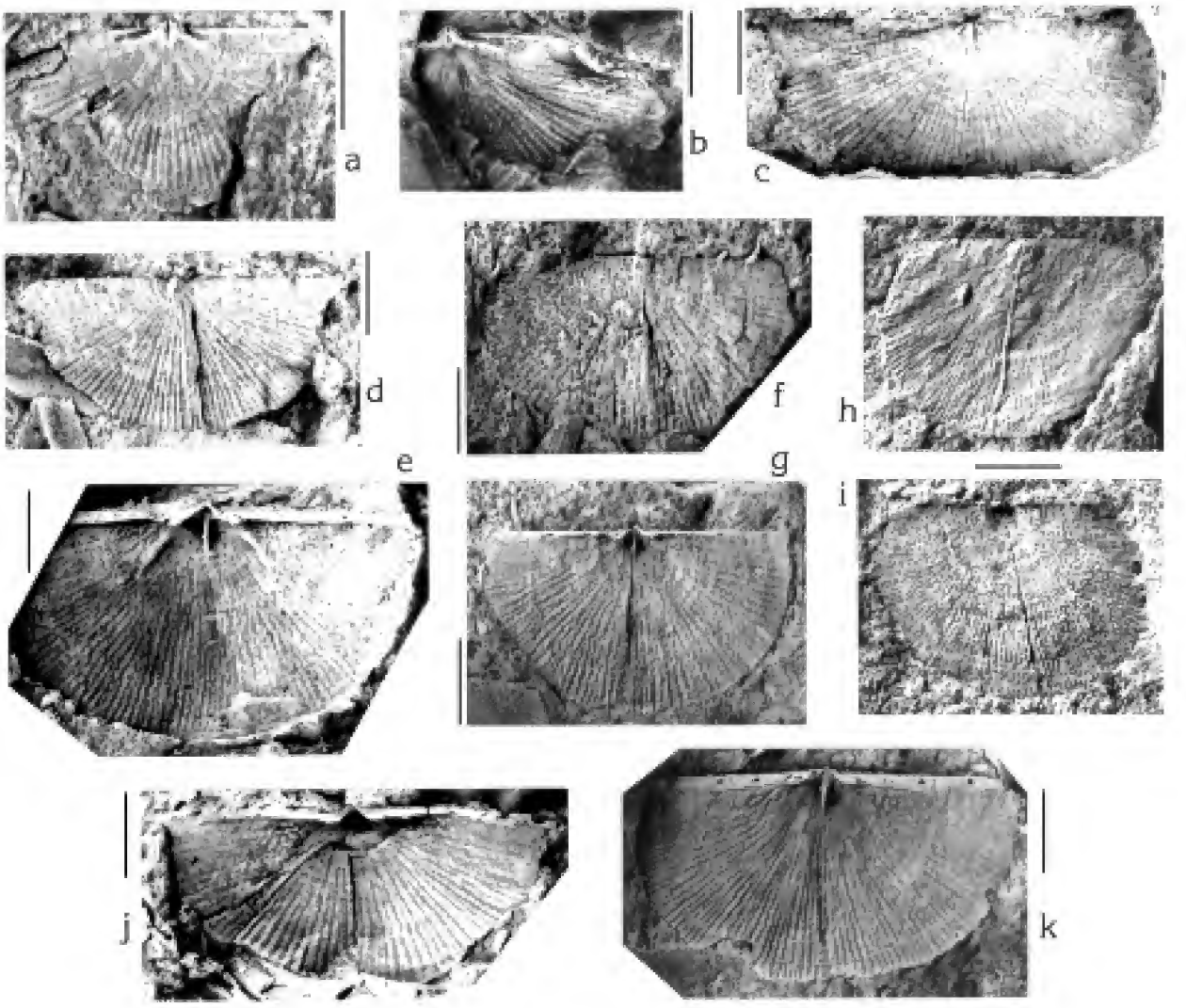

Figure 4. **a–k**: *Strophochonetes kemezysi*; **a**, holotype ANU 9619, latex from incomplete dorsal internal mould; **b**, paratype ANU 9617, latex from incomplete dorsal internal mould; **c**, paratype ANU 9626, latex from dorsal external mould; **d**, paratype ANU 9630, latex from ventral external mould; **e**, paralectotype ANU 9621, latex from ventral internal mould; **f,g**, paratype ANU 9625, latexes from ventral external and internal moulds; **h,i**, NMV P79776, latex from ventral external mould, and counterpart P79775, latex from ventral internal mould; **j**, paratype ANU 9623, latex from ventral internal mould; **k**, paratype ANU 9622, latex from ventral internal mould. Rainbow Hill Member, Rosebank Shale; Ludfordian. Scale bars 2 mm.

bifurcation. The most obvious external distinction is the greater strength of protegular structures in *S. kemezysi*. The greatest differences are internal: *S. kemezysi* has a shorter ventral median septum, more robust inner socket ridges which do not curve parallel to the hinge, and less divergent anderidia. The papillae are finer, and those posterolateral to the muscle field are not as prominent.

All species of similar size and age in Europe are nearly plano-convex, like *S. melbournensis*, and similarly lack prominent protegular nodes. Internally, *S. kemezysi* is distinctive in having inner socket ridges which, while strongly divergent, do not curve to become parallel to the hinge line; I do not consider this alone to be sufficient to remove it from the genus. The Devonian Siberian species noted in comparison with *S. melbournensis* are apparently as convex as *S. kemezysi*, and also have short ventral median septa, but are much more coarsely ribbed.

Strophochonetes sp. Sherwin, 1995

Strophochonetes sp. *sensu lato* Sherwin, 1995: 79, fig. 14.

Material. MMF31387, from locality TM 151, "The Meadows" area about 50 km WSW of Cobar; The Meadows 1:100,000 sheet, grid reference 455.995.

Stratigraphic distribution. Winduck Group, Cobar Trough, western New South Wales.

Age. Lochkovian, Early Devonian.

Discussion. Based on several poorly preserved ventral valves on a single slab of fine sandstone, this is a small moderately convex form with capillae increasing by intercalation, the median capilla slightly enlarged; one specimen has a single spine base preserved. The ventral interior has small teeth, a short low and very thin median

septum, and obscure muscle field. It differs from the older species *S. melbournensis* in the mode of increase of its somewhat coarser and fewer capillae, and in its obscure muscle field. *Strophochonetes? psiloplia* is too poorly known for useful comparison, but is of comparable age. I retain the form in *Strophochonetes* on the presence of a slightly enlarged ventral median capilla and poorly developed ventral median septum, but its known features are not really sufficient for confident identification.

Strophochonetes? savagei n.sp.

Figs. 3, 5

Chonetes cresswelli.–Savage, 1974: 29–31, pl. 7, figs. 1–20 (*non* Chapman, 1903).

Type material. HOLOTYPE AM F67255 (Fig. 5; formerly SU P34541), a ventral internal mould figured Savage, 1974, pl. 7, figs. 11–12. PARATYPES AM F67251–54, 67256–61, 67427 (SU P34535–37, 34540, 34542–48); figured specimens SU P34534 and 34538–39 were not transferred to the Australian Museum, and are presumed lost. All from Savage's locality 3, where the Manildra–Canowindra road crosses Mandagery Creek 600 m south of Manildra.

Stratigraphic distribution. Manildra Formation, Cowra Trough, central New South Wales

Age. *Boucotia janaea* Assemblage Zone (Garratt & Wright, 1988), Early Lochkovian (probably pre-*eurekaensis* Zone—see Mawson *et al.*, 1988), Early Devonian.

Etymology. Named for Dr N. Savage, in honour of his pioneering work on Siluro-Devonian brachiopods from central New South Wales.

Diagnosis. Small, gently plano-convex, capillate *Strophochonetes?* with distinct median ventral capilla, robust variably cyrtomorph hinge spines, short ventral median septum, strongly cleft cardinal process, small cardinal process pit, and strong inner socket ridges almost parallel to hinge line.

Summary description (modified after Savage, 1974). Shell very small, semicircular to subquadrate, gently concavo-convex to plano-convex. Ls to 5 mm, Ws to 8 mm; maximum width at hinge line. Ventral interarea low apsacline, dorsal interarea almost non-existent. Hinge spines few; bases usually outwards-oblique but variable; spines variably intraverse cyrtomorph to straight and oblique or extraverse cyrtomorph (distally upright).

Ornament capillate; about 40 capillae at 4 mm radius, increasing by intercalation and bifurcation. Ventral median capillae usually prominent.

Ventral interior with narrow median septum extending to about ⅙ valve length. Teeth and muscle fields obscure, valve floor papillose, the papillae aligned beneath capillae, and most prominent posterolaterally.

Dorsal interior with strongly bifid cardinal process continuous with robust straight inner socket ridges which are almost parallel to hinge. Anderidia narrow, low, diverging forward at about 40°. Small cardinal process pit. Outer part of valve floor finely and radially papillose.

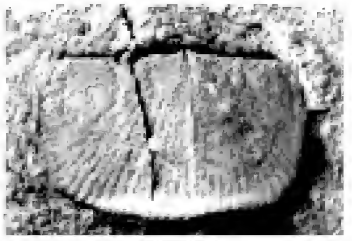

Figure 5. *Strophochonetes? savagei*; holotype AM F67255 (formerly SU P34541), ventral internal mould; photograph courtesy Zhen Yongyi. Manildra Formation; early Lochkovian. Scale bar 2 mm.

Discussion. The hinge spines are very variable, but apparently mostly cyrtomorph. In one specimen, a prominent spine near the beak is oblique intraverse and almost straight, whereas in another a similarly-placed spine, initially oblique intraverse, curves so that the distal part is straight and upright. A third specimen has one well-preserved intraverse cyrtomorph spine at the left-hand end of the cardinal margin. Spine bases on others vary from intraverse through upright to extraverse. Only one dorsal interior is known, so the generic position remains a little uncertain. With that slight reservation, the species is referred to *Strophochonetes* on the basis of generally oblique hinge spines, enlarged median capilla, non-bifid ventral median septum, inner socket ridges almost parallel to hinge line, and distinct divergent anderidia.

Strophochonetes? savagei differs from *"S." cresswelli* because of the prominent median rib on the ventral valve, more variable hinge spines, and relatively longer inner socket ridges. It is also about half the size. It differs from *S. melbournensis* and *S. kemezysi* in being somewhat smaller, with more robust and apparently more strongly cyrtomorph hinge spines. The former has a longer ventral median septum, the latter has less strongly divergent inner socket ridges. The poorly known *S.? psiloplia* is larger, with nearly upright hinge spines.

Strophochonetes? psiloplia (Gill, 1945)

Figs. 3, 6

Chonetes (Chonetes) psiloplia Gill, 1945: 138–139, pl. VIII, fig. 15.

Type material. HOLOTYPE NMV P14519, from locality PL1834, Syme's Tunnel, Seville East, east of Lilydale.

Stratigraphic distribution. Humevale Formation (in grey siltstone), Melbourne Trough, central Victoria.

Age. Lochkovian, Early Devonian.

Diagnosis. Small *Strophochonetes?*, moderately concavo-convex with relatively strongly concave dorsal valve, nearly semicircular outline, long orthomorph nearly upright hinge spines, small ventral median septum and obscure ventral muscle field.

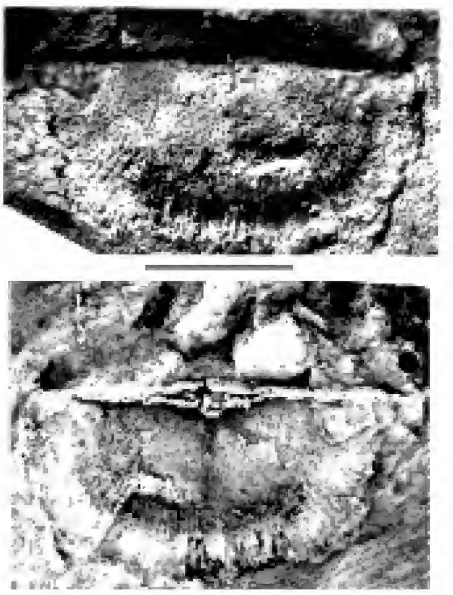

Figure 6. *Strophochonetes? psiloplia*; holotype NMV P14519, crushed ventral internal mould (plus mould of dorsal interarea and umbo) and latex replica. Humevale Formation; Lochkovian. Scale bar 5 mm.

Description. Shell moderately concavo-convex with little space between valves; Ls 7.3 mm, Ws 13.2 mm (Ls/Ws 0.55), Ds c. 1.5 mm (Ds/Ls 0.2); outline nearly semicircular. Apparently weakly alate, but width at mid-length equals width at hinge line; shallow re-entrants between ears and lateral commissure. Ventral interarea apsacline, low; beak apparently small; dorsal interarea anacline. Delthyrial and notothyrial structures and cardinal process obscure. Indication of fairly prominent dorsal protegular node. One long apparently orthomorph almost upright (α c. 85°) spine partly preserved. Ornament capillate but not measurable, although seemingly somewhat coarser than in *S. melbournensis*; enlarged median capilla apparently present.

Ventral interior poorly known. Fine median septum reported by Gill not now visible, so cannot have been very long. Ventral muscle field obscure. Valve floor covered with small radially arrayed papillae.

Dorsal interior unknown.

Discussion. The holotype is the only specimen. Described by Gill as a ventral valve, it is actually a poorly preserved internal mould in ventral aspect (effectively a ventral internal mould), slightly flattened and damaged near the umbos so that an external mould of both interareas and the proximal part of the dorsal valve is visible. In size and outline it is not greatly dissimilar from *S. melbournensis*, differing most obviously in the almost upright and probably straight hinge spines, and the greater curvature of the dorsal valve; the ribbing seems to be somewhat coarser, and the dorsal valve more strongly concave. Until more detail is available, even the generic position must remain uncertain, but in view of the similarity with *S. melbournensis* assignment to *Strophochonetes* seems most appropriate. It is conceivable that the two are synonymous.

"Strophochonetes" cresswelli (Chapman, 1903)

Figs. 3, 7

Chonetes cresswelli Chapman, 1903: 77–78, pl. XII, fig. 7d; Gill, 1951: 60–61, pl. III, fig. 5.
Chonetes (Chonetes) cresswelli.–Gill, 1945, 134–135, pl. VIII, fig. 5.
Protochonetes? cresswelli.–Boucot & Harper, 1968: 151.
Protochonetes cresswelli.–Chatterton, 1973: 73.
"Protochonetes" cresswelli.–Garratt, 1983: 88 (in fig. 5 referred to as *"Parachonetes"*).
non? *Chonetes cresswelli*.–Philip, 1962: 214–215, pl. XXXII, figs. 7–9.
non *Chonetes cresswelli*.–Savage, 1974: 29–31, pl. 7, figs. 1–20.

Type material. LECTOTYPE NMV P652 (Fig. 7a,b; figured Chapman, 1903, pl. XII, fig. 7), a ventral internal mould, and PARALECTOTYPES NMV P653–55, 1422–23, all from locality PL1803, Hughes Quarry north of Lilydale, Chirnside Park (at the summit of a low hill near the middle of a block bounded by the northern end of Edward Road, Coldstream West Road, and Victoria Road); Christmas Hills 1:25,000 sheet, grid reference 528239. Lectotype selected Gill (1945: 134), by reference to it as "holotype" (ICZN Rule 74b); re-figured Gill (1951, pl. III, fig. 5).

Other material. NMV P14712A, B, 15133, 25552, 33117–19, 33123, 77010, all from locality PL1802—Gill's Locality 2, "Wilson's" near Lilydale (an excavation on Albert Hill Road about 400 m east of its intersection with Victoria Road); Ringwood 1:100,000 sheet, grid reference 535196.

Stratigraphic distribution. Humevale Formation, Melbourne Trough, central Victoria.

Age. Lochkovian and Pragian, Early Devonian.

Diagnosis. Small, moderately concavo-convex, gently sulcate, finely costellate shells with symmetrically placed hinge spines, usually proximally intraverse cyrtomorph becoming upright distally, no enlarged ventral median costa; ventral median septum short, high and thickened but not bifid posteriorly; no dorsal median septum, but sometimes a low, narrow breviseptum; straight anderidia diverge anteriorly at 30–50°.

Description. Shell small (Ls to 10 mm, Ws to 15 mm), ovate, length about ⅔ width, hinge line less than maximum width (which is at about 40% of length); cardinal angles obtuse. Ventral valve moderately to strongly convex (depth 0.2–0.4 length), dorsal valve gently to moderately concave (depth up to ⅓ length), body cavity shallow. Broad, shallow, commonly gently V-shaped ventral sulcus often present. Ventral beak small; interarea low, flat, orthocline to apsacline; delthyrium triangular, with narrow arcuate pseudodeltidium. Dorsal interarea very low, flat, anacline; myophore with median furrow deeper than lateral furrows, and flanked by narrow chilidial plates; small, narrow protegular node. Hinge spines long and fairly thin; attitude variable, but generally proximally steeply oblique and intraverse cyrtomorph, becoming upright distally; up to 3 seen on each side of umbo, symmetrically placed.

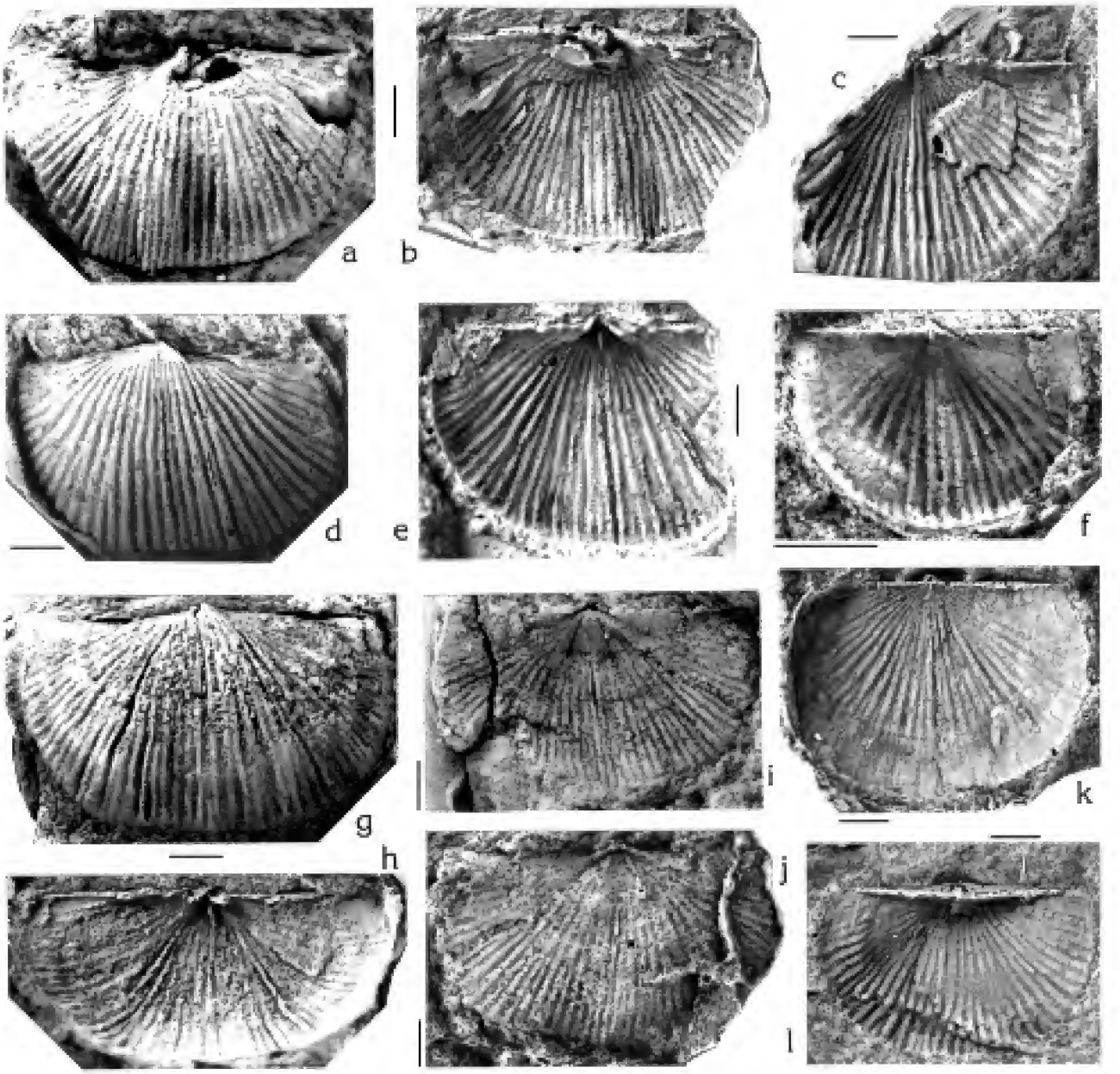

Figure 7. a–l: *"Strophochonetes" cresswelli*; **a,b**, lectotype NMV P652, ventral internal mould and latex replica; **c**, paralectotype NMV P1422, latex from ventral internal mould; **d**, NMV P15133, ventral internal mould; **e**, paralectotype NMV P654, latex from ventral internal mould; **f**, NMV P33117, latex from dorsal external mould—note marginal zone of subdued ornament; **g,h**, paralectotype NMV P1423, ventral internal mould and anterodorsal view of latex replica; **i,j**; NMV P14712A, dorsal internal mould and latex replica; **k**, paralectotype NMV P653, latex from dorsal external mould; **l**, paralectotype NMV P655, latex from dorsal external mould. Humevale Formation; Lochkovian to Pragian. Scale bars 2 mm.

Radial ornament costellate; ribs fine, rounded, lowest near cardinal angles and slightly more crowded medially than laterally. Ribs on dorsal valve opposed to furrows on ventral valve (clearly visible on NMV P1422); increase on the latter by bifurcation and consequently by intercalation on the former; about 20–22 costae increase to about 50–60 ribs marginally. At 5 mm radius generally 11–12 ribs in 5 mm medially. Ribs weaker near margin in some specimens, almost absent in distinct submarginal zone in a dorsal external mould. Fine growth lines noticeable mainly near hinge margin.

Ventral interior with well-developed strongly divergent teeth supported by very short divergent dental plates. Median septum thin, reaches to about ¼ valve length, posteriorly high and thickened, anteriorly very low. Ventral muscle field subtriangular, moderately impressed posteriorly, obscure anteriorly, its floor only slightly less corrugated by external ribs than remainder of valve floor. Outer half of valve floor finely papillose.

Dorsal interior with distinct anderidia diverging at about 30–50° from base of small elevated cardinal process, and reaching to about ¼ valve length; distal ends of anderidia

swollen. Of two known dorsal interiors, NMV P14712A (Ld = 8.3 mm.) has very low median breviseptum extending from ⅓ to ⅔ Ld, NMV P25552 (Ld = 5.5 mm) shows no sign of a median septum. No cardinal process pit or accessory septa. Inner socket ridges narrow, high, fused to cardinal process, straight and strongly divergent. Outer parts of valve floor very finely papillose.

Discussion. The position of this species is still uncertain, partly because of relatively poor preservation of much of the available material. Earlier (Strusz, 1984: 133) I remarked that Chatterton's (1973) assignment to *Protochonetes* was incorrect and Savage's (1974) to *Chonetes* correct, in the belief that there were upright spines and a cardinal process pit, but subsequent examination shows this to be incorrect. In shell shape, ornament (except the lack of an enlarged median costa), distally parallel cyrtomorph hinge spines, and internal structures this species is similar to a number of Early Devonian strophochonetines, but the particular combination of structures is shared by none of them. The undifferentiated median costa suggests the Protochonetinae, but all protochonetines have orthomorph oblique hinge spines and weakly divergent anderidia.

"Strophochonetes" cresswelli differs from typical *Strophochonetes* in having no cardinal process pit, a weakly developed dorsal breviseptum, and anderidia attached to the cardinal process. *Ctenochonetes* Racheboeuf, 1976, has orthomorph spines, the first two present on only one side of the umbo; although its cardinal process is supported by well-developed anderidia as in *"S." cresswelli*, it also has a well-developed median septum; moreover, the sockets are partly covered ventrally by flaps developed from the inner socket ridges. In *Johnsonetes* the median costa is not prominent, being enlarged only umbonally, and the cardinal process is supported by the anderidia, but in it too the first two hinge spines are inserted only to one side of the umbo, and the dorsal median septum is much better developed.

Similar in size, ornament, shallow ventral sulcus and ventral internal structures is *"Strophochonetes" longispina* (Mansuy, 1912) as revised by Racheboeuf & Thanh (in press). That species, however, has more closely spaced upright hinge spines, and a distinct posteriorly widened median septum supporting the cardinal process.

It is likely that *"S." cresswelli* is a generically distinct strophochonetine, but erection of a new genus requires better material than is currently available.

The three ventral internal moulds from the Lochkovian Boola Formation of the Tyers area, East Gippsland, ascribed to this species by Philip (1962: 214–215, pl. 32, figs. 7–9) are less convex, with the external ornament only weakly reflected on the coarsely papillose valve floors. They differ most markedly in the hinge spines, which are inwards-oblique, and on this account alone are considered unlikely to be conspecific with *"S." cresswelli*. In the absence of dorsal valves the identity of Philip's species remains unknown, but the hinge spines suggest possible comparison with the Vietnamese Early Devonian *Bacbonetes janvieri* Racheboeuf & Thanh (in press).

The specimens described by Savage (1974) from the Lochkovian Maradana Shale of central New South Wales are rejected from *P.? cresswelli* because there is a prominent median rib on the ventral valve, and the inner socket ridges are significantly longer. They form the basis of the new species *Strophochonetes? savagei*, described herein.

Johnsonetes Racheboeuf, 1987

Type species. *Chonetes filistriata* Walcott, 1884. Emsian, Nevada.

Diagnosis. "Shell small to medium, markedly concavo-convex and transverse in outline; when present, median enlarged costa developed on beak only; spines orthomorph vertical, asymmetrically arranged with more spines on one side; homologous spines appearing first on the opposite side; long and thin dorsal median septum supporting a stout, short and wide cardinal process; inner socket ridges low, rounded, anteriorly divergent at 130–140°; anderidia short, anteriorly divergent at 45–50° and posteriorly fused with cardinal process." (Racheboeuf, 1998: 41).

Remarks. Racheboeuf (1987) assigned four species to *Johnsonetes*: the type species from Nevada, two new Emsian species from the Canadian Arctic Archipelago, and *Protochonetes latus* Chatterton, 1973, from the Emsian (not Pragian) of Australia. In the quoted diagnosis one of the characteristics is that the hinge spines are vertical to the hinge. The specimens of *J. filistriata* figured by Johnson (1970, pl. 31, figs. 1–17) suggest this to be the case, though few of the figured ventral valves show much more than spine bases. As recorded below, it is not the case with Chatterton's species. In *J. ellesmerensis* Racheboeuf, 1987, the spines are proximally upright or very steeply oblique extraverse, but then bend inwards to become orthomorph intraverse. The holotype of *J. arcticus* Racheboeuf, 1987 (his pl. 1, figs. 19–21) suggests steeply oblique spines, possibly cyrtomorph intraverse. In all other respects these species appear to be congeneric. If the genus is to be redefined to include species with oblique spines, then I would also include in it the Australian species *Chonetes australis* McCoy, 1876, and *Chonetes culleni* Dun, 1904. With *Protochonetes latus* these form a group of very similar species. To that group I would tentatively add *Devonochonetes?* sp. 2 Lenz & Johnson, 1985, from the Pragian of New South Wales, in agreement with Racheboeuf (1998: 41). I disagree with Racheboeuf in also assigning *Devonochonetes?* sp. 1 Lenz & Johnson, 1985, to *Johnsonetes*. In view of these changes, I have provided redescriptions of all the species concerned.

Johnsonetes australis (McCoy, 1876)

Figs. 8, 9

Chonetes australis McCoy, 1876: 141–142, pl. XXXV, figs. 3–5; Gill: 1951, 64–68, pl. III, figs. 18, 19, 21; Talent, 1956: 41–43, pl. III, figs. 10, 11.
Chonetes (Chonetes) australis.–Gill, 1945: 136.
Chonetes teicherti Gill, 1951: 70–71, pl. III, figs. 12–15.
Protochonetes australis.–Chatterton, 1973: 71.
"Chonetes" teicherti.–Chatterton, 1973: 77.

Type material. The two ventral valves figured by McCoy have been missing for many years (see Gill, 1945: 136);

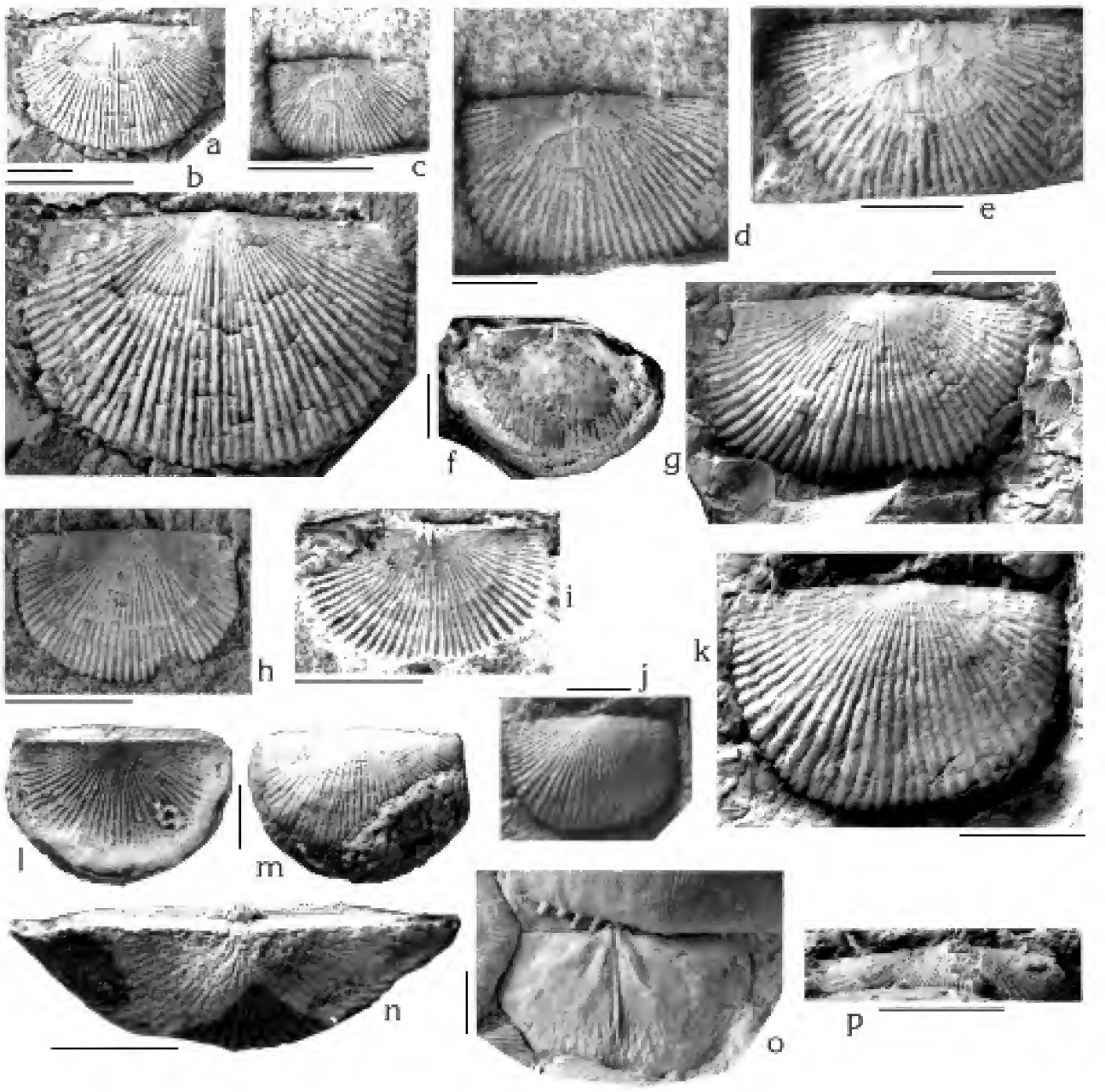

Figure 8. **a–p**: *Johnsonetes australis*; **a,b**, neotype NMV P134773, ventral valve with well-preserved protegulal structures; **c–e**, holotype NMV P123136 of *Chonetes teicherti*, latex from ventral external mould (c,d) and partially decorticated ventral valve (e) showing very distinct protegulal structures; **f**, NMV P1222, calcined and partly decorticated ventral valve; **g**, NMV P127638A/1, ventral valve on paratype slab of *Chonetes teicherti*; **h**, NMV P79717, ventral valve showing distinct protegulal structures; **i**, NMV P127952, dorsal valve with distinct protegulal structures; **j,k**, NMV P127638B/2, ventral valve on paratype slab of *Chonetes teicherti*; **l–n**, NMV P127544, isolated shell in dorsal, ventral and posterior aspects (showing chilidial plates); **o**, NMV P127543/3, dorsal valve on slab, showing anderidia on crests of low ridges; **p**, NMV P34619, posterior part of ventral valve. Buchan Group; Emsian. Scale bars 2 mm (d,e) and 5 mm.

the last reference to their being available is by Dun (1904, p. 322), who noted that Chapman "compared a specimen of *C. culleni* with McCoy's type". Searches in 1984 and 1997 have been unsuccessful, and both specimens must be considered lost. To permit comparison of McCoy's species with *Protochonetes culleni* (Dun) I here select a neotype. NEOTYPE NMV P134773 (Fig. 8a,b; formerly GSV 47639), a ventral valve collected by Curt Teichert from just below the top of the Buchan Caves Limestone in Slocombe's Creek, 800 m north of East Buchan Road, Buchan, East Gippsland, figured by Gill (1951, pl. III, fig. 19).

Type material of *Chonetes teicherti* Gill. HOLOTYPE NMV P123136A+B (Fig. 8c–e; formerly MUGD 1979, 1980), a ventral valve and counterpart external mould from Moon Rd, Buchan (Gill, 1951, pl. III, figs. 12, 13). PARATYPES

NMV P127638A+B (formerly MUGD 1982, 1983), counterpart slabs with crowded dissociated valves from McLarty's Gully, near Murrindal, Buchan; the one valve figured by Gill (1951, pl. III, figs. 14, 15) cannot be recognised.

Other material. *Previously figured specimens*. NMV P1222, a calcined worn ventral valve from Buchan (Gill, 1951, text-fig. 7); P15134, a badly corroded silicified ventral valve from Buchan (Gill, 1951, text-fig. 6); P34619 (formerly GSV 47556), posterior part of a ventral valve from just south of Buchan Caves Reserve (Gill, 1951, text-fig. 4); P127544 (formerly MUGD 2183), a free shell from Davidson's Cliff, Jackson's Crossing, Buchan District (Talent, 1956, pl. III, figs. 10, 11); P127952 (formerly MUGD 1984), a dorsal valve from north of the north end of Moon's Road, Buchan (Gill, 1951, pl. III, figs. 18, 21).

Unfigured specimens. NMV P1264 (Buchan), P79710 (Slocombe's Creek, Buchan), P79714–15, P79717–20 (Buchan), P79723–25 (about 800 m northwest of the top of Moon's Rd, East Buchan), P79726 (ex GSV 47556, from south of Fairy Cave, Buchan), P80094–98 (Buchan), P127543 (Buchan?, ex MUGD 2185; cited Talent, 1956, p. 43).

Stratigraphic distribution. Buchan Caves Limestone and Taravale Mudstone, Buchan Group, Buchan Rift, eastern Victoria.

Age. Emsian, Early Devonian.

Diagnosis. Medium-sized moderately convex species of *Johnsonetes* with convexity increasing with size; all except median rib arising outside pronounced ventral protegulum; ribs steadily increase in size with growth, median costa becoming undifferentiated beyond adult midlength; 4–7 hinge spines each side of beak, spine 1 very fine and upright, spine 1' absent, remainder orthomorph oblique, robust, asymmetric; ventral interarea flat; inner socket ridges relatively long; prominent notothyrial platform; anderidia raised on broad ridges.

Description. Shell medium-sized (Ls to 16 mm, Ws to 28 mm), subovate (Ls/Ws mostly 0.6–0.8), with greatest width either at hinge line (where small alae are often developed) or towards midlength (when alae are absent). Small shells only moderately convex (Ds/Ls c. 0.15 for Ls <5 mm), but as shell size increases so does convexity, Ds/Ls reaching 0.3 or more for Ls about 12–14 mm (equivalent to Ws of 17–22 mm). Weak anterior ventral sulcus in some larger shells. Shell in large specimens relatively thick. Ventral umbo comprises slightly raised protegular region of about 0.8–1 mm radius, ornamented only by strong growth lines and median costa. Ventral interarea low, triangular, apsacline to orthocline, and flat; delthyrium wide, pseudodeltidium crescentic, distinctly raised. Dorsal umbo flat, with prominent elliptical protegular lobe and lateral nodes (terminology of Kemežys, 1965), ornamented only by strong growth lines; interarea very low, flat, anacline, with wide notothyrium flanked by narrow, triangular chilidial plates; myophore quadrilobate, central lobes larger than outer ones.

Hinge spines developed in alternating manner described by Chatterton (1973) and Garcia-Alcalde & Racheboeuf (1975); innermost (spine 1) very fine and upright or steeply intraverse, 1' absent, remainder oblique orthomorph and fairly robust, α usually 75–80° but can be as low as 50°; spine bases more strongly oblique than spines.

Ornament costellate, ribs increasing steadily in size distally, and occasionally in number by bifurcation; at 5 mm radius usually 11–16 (mostly 12–14) ribs in 5 mm; a shell 9.8 mm long has about 54 ribs at margin, spaced only 9 in 5 mm medially. Median costa arises at beak, remainder radiate from margin of protegulal area. Ventral median costa somewhat enlarged proximally, but does not increase in size at same rate as others, so by about midlength in larger shells is no longer distinctive.

Ventral interior with robust triangular teeth without supporting plates. Median septum short, thickened posteriorly. Muscle field smooth-floored, flabellate, moderately impressed and with sharp margins posterolaterally.

Dorsal interior with prominent, moderately curved inner socket ridges which are distally flared and subparallel to hinge line. Sockets deep, conical; outer socket ridges fine, slightly raised. Cardinal process short, wide, deeply bifid, raised on prominent notothyrial platform which is fused to inner socket ridges and is often axially furrowed; no cardinal process pit. Anderidia fine, detached from cardinal process but rest on very prominent broad ridges extending from notothyrial platform; anderidia diverge at about 30–50°. Prominent depressions separate these ridges from inner socket ridges and median septum. Anderidia reach up to one third valve length, their supporting ridges may extend almost to midlength. Median septum proximally low, narrows and rises forward to midlength or beyond; distal end low but distinct, may reach 80% Ld. Adductor muscle scars small, triangular, confined by anderidia and median septum, gently impressed. Beyond median septum, anderidial ridges and inner socket ridges, valve floor bears coarse, elongate, radially arranged papillae; shallow furrow, continuous with depressions anteromedian to inner socket ridges may define inner margin of this papillose zone (Fig. 7o).

Discussion. McCoy's species is assigned to *Johnsonetes* because of the asymmetric insertion of hinge spines and absence of spine 1', and its short, wide cardinal process supported by divergent rounded inner socket ridges, and median costa only enlarged posteriorly. In common with *J. latus* Chatterton, 1973, which was unequivocally assigned to *Johnsonetes* by Racheboeuf (1987), it differs from the type species by its oblique hinge spines. In that feature and the only weakly enlarged median costa it also recalls *Novellinetes* Havlíček & Racheboeuf, 1979, from the Emsian of Bohemia. However that genus has only three spines, very fine ornament, a strongly impressed ventral muscle field, very small anderidia, a deep cardinal process pit but no dorsal median septum, and long, narrow inner socket ridges which are almost parallel to the hinge line. *Ctenochonetes* Racheboeuf, 1976, a widespread Old World Province Early Devonian genus, is similar in overall appearance, but has perpendicular spines of which the first two are absent to one (usually the left) side of the umbo, and dental sockets overhung by flap-like extensions of the inner socket ridges.

Gill (1951) based *Chonetes teicherti* on specimens on two slabs of black limestone from different localities in the

Buchan district of Victoria, specifying amongst the distinguishing characters small size (Ws to 6 mm), prominent protegulal structures, and only two spines on the right side of the ventral valve. He also noted that the species occurred "on the same slabs" as specimens assigned to *C. australis*, being readily distinguished by its smaller size. The figured paratypes NMV P127638A+B are unrecognisable on a slab crowded with other valves, mostly small but including several larger than 6 mm. However, all show the same pronounced ventral protegulum crossed only by the median costa. Plots of Ls and Ds against Ws for all Buchan specimens previously ascribed to *C. australis* and *C. teicherti* show no differentiation. Comparison of the types of the two forms (neotype NMV P134773, Fig. 8b, and holotype NMV P123136, Fig. 8c) shows no distinguishing features. Gill's type, moreover, does show traces of spine 2', so spine insertion is the same as found in *Johnsonetes australis*. I consider that *C. teicherti* is the juvenile form of *J. australis*.

Comparison. *Johnsonetes australis* is very similar to *J. culleni*, to the extent that Brock & Talent (1993: 236) considered them synonymous. Their relationship is discussed following the description of *J. culleni*.

Protochonetes sp. Brock & Talent, 1993, from the Emsian of Queensland, is similar in size and proportions to *J. australis*, and their fig. 11D suggests the same tendency to develop a sulcus. The dorsal internal structures and type of hinge spine are unknown; the ventral muscle field seems to be somewhat less distinct, and the median septum finer and longer than in *J. australis*. Better material is needed before its generic relationships can be determined.

Johnsonetes culleni (Dun, 1904)

Figs. 9, 10

Chonetes Culleni Dun, 1904: 321–323, pl. 61, figs. 1, 1a.
Protochonetes culleni.–Chatterton, 1973: 69–73, pl. 16, figs. 1–22.

Type material. Dun's syntypes comprise MMF4002, a number of disarticulated valves on a slab of yellowish-grey buff-weathering argillaceous limestone, associated with *Spinella yassensis* (De Koninck, 1877). Dun figured one ventral valve exterior (fig. 1) and one partly obscured dorsal valve interior (fig. 1a). The type locality is portion 65, Parish of Taemas, southwest of Yass, N.S.W. As noted by Chatterton (1973), this is about 1.5 km south of "Taemas" homestead on the now abandoned road from Mountain Creek to the old Taemas Bridge, at (or close to) a locality long known as "Shearsby's Wallpaper"—see also Strusz *et al.* (1970). LECTOTYPE (here chosen) MMF4002A, the original of Dun's fig. 1 (Fig. 10a). PARALECTOTYPES are all the remaining valves on the slab, numbered MMF4002B–I; F4002B is the original of Dun's fig. 1a (Fig. 10b,c).

Other material. Topotypes ANU 18947a–c and CPC 10558, figured by Chatterton (1973, pl. 16, figs. 15–22). Figured specimens ANU 18945a–f, CPC 10559–62 from the *Receptaculites* Member, Taemas Formation (Chatterton, 1973, pl. 16, figs. 1–14).

Stratigraphic distribution. *Spirifer yassensis* and basal *Receptaculites* Limestone Members, basal and middle Taemas Formation, Canberra-Yass Shelf, southeastern New South Wales.

Age. *Polygnathus dehiscens* Zone, Early Emsian, Early Devonian (Mawson *et al.*, 1992).

Diagnosis. Medium-sized costellate species of *Johnsonetes* with all costae radiating from beak, the median costa little differentiated even umbonally; up to seven asymmetrically arranged robust orthomorph oblique hinge spines either side of umbo, spine 1' absent; ventral interarea concave; prominent notothyrial platform, posteriorly widened dorsal median septum; prominent geniculate anderidia not raised on ridges.

Description. Shell medium-sized (Ls to 15 mm, Ws to 20 mm), concavo-convex, subovate (Ls/Ws mostly 0.6–0.8); small alae common. Greatest width mostly towards midlength, but may be at hinge when alae more extended than usual—in which case cardinal extremities generally less convex than remainder of ventral valve. Adult shells moderately to strongly convex, Ds/Ls 0.35–0.5. Ventral valve thicker than dorsal valve. Faint ventral sulcus in silicified specimens from basal *Receptaculites* Limestone Member. Ventral umbo low, protegulum not differentiated; interarea low and weakly concave, apsacline to orthocline. Delthyrium broad, triangular (apical angle 80–100°), constricted laterally by bases of hinge teeth and apically by small but often high pseudodeltidium whose distal margin reflects shape of myophore. Dorsal umbo flat, protegular node insignificant, lateral nodes absent; interarea almost linear, anacline. Notothyrium wide, myophore triangular, quadrilobed and flanked proximally by narrow cardinal crests; chilidial plates narrow, triangular, only developed in apical half of notothyrium.

Hinge spines robust, orthomorph to very weakly cyrtomorph intraverse, oblique. Lectotype shows six spines on each side, those on left being best preserved, the spines uniformly oblique, α = 50–60°. Paralectotypes less well preserved but show same spine form, α up to 75°. Spine insertion alternate, as in *J. australis*, spine 1 very fine (often not preserved), 1' absent. Chatterton reported up to seven spines on each side, and noted that α decreases outwards to as little as 40°, with some tendency for outermost spines to be cyrtomorph intraverse.

Ornament fine, costellate, with 11–16 ribs in 5 mm at 5 mm from umbo. Both bifurcation and intercalation uncommon, so that ribs increase steadily in size distally; about 56 at margin in lectotype. Costae arise at beak; median costa not enlarged.

Ventral interior with triangular teeth extending only moderately beyond corners of delthyrium, and without supporting plates. Median septum short; proximally broad and flat-topped but only occasionally furrowed, narrowing and at first rising forward, then rapidly becoming lower and finer; length generally about a fifth and does not exceed a quarter of valve length. Muscle field flabellate, moderately impressed posterolaterally; adductor scars, where clearly differentiated, small, ovate, enclose anterior part of median septum, and are surrounded by diductor scars. Low ridges bounding posterolateral parts of muscle field in some specimens. External ornament strongly impressed on valve floor; coarse elongate papillae outside muscle field aligned beneath inter-rib furrows.

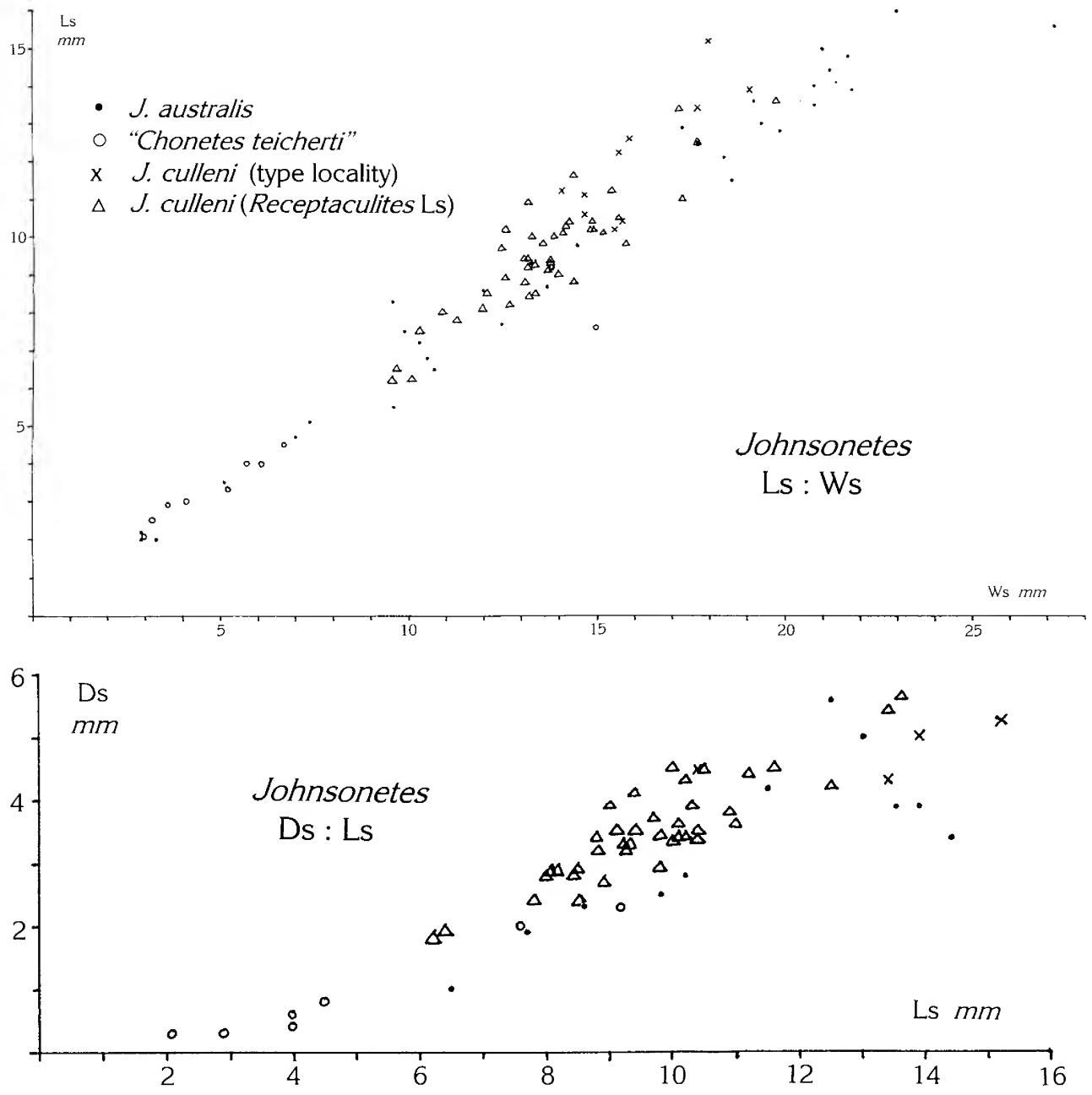

Figure 9. Scatter diagrams of shell length against width, and depth against length, for species of *Johnsonetes*. Points for shells originally assigned to *Chonetes teicherti*, and for topotypic and non-topotypic *J. culleni*, are given distinct symbols.

Dorsal interior with strong, rounded inner socket ridges diverging from hinge line at about 25–30°, and prolonged beyond sockets as broad low ridges. Socket ridges fused proximally to low notothyrial platform, from which arises short, wide cardinal process. Platform either smooth-topped or with shallow median groove continuous with furrow between process lobes; no cardinal process pit. Median septum extends from front of platform; initially low and broad, it becomes narrower and higher forward before dropping relatively abruptly, finally dying out a little beyond midlength. Prominent anderidia diverge from base of septum, generally at 25–30° (40° in the one paralectotype dorsal interior). Anderidia more strongly divergent anteriorly than posteriorly, changing divergence at point of greatest height (at about 30% of valve length); low anterior sections can extend almost to midlength. Forward ends of posterior sections often swollen, and bear co-linear low-angle spinose protuberances ending just behind junctions with anterior sections. Valve floor strongly corrugated by reflection of inter-rib furrows, with coarse papillae aligned on them distally, as in ventral valve.

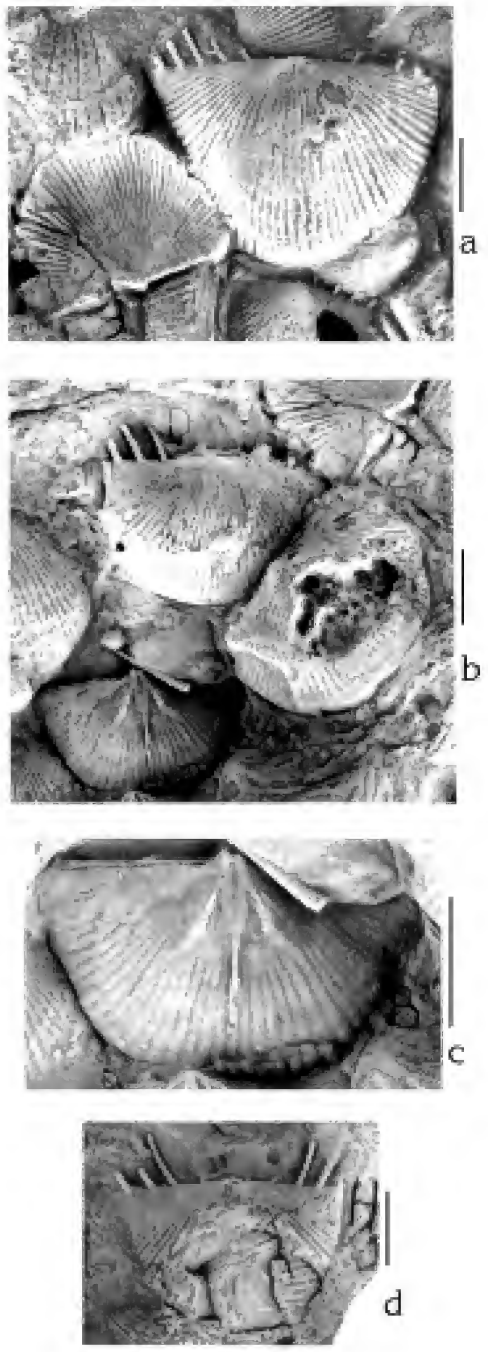

Figure 10. a–d: *Johnsonetes culleni*—syntype slab MMF4002. Note that the letter suffixes for individual valves have been scratched into adjacent rock, and can be seen on the photos. **a**, lectotype ventral valve MMF4002A at right, paralectotype dorsal valve MMF4002F (left) and ventral valve MMF4002G (bottom); **b**, paralectotype dorsal valve MMF4002B (bottom left) and ventral valves MMF4002D, E; **c**, paralectotype dorsal valve MMF4002B; compare Fig. 7o; **d**, paralectotype ventral valve MMF4002H. *Spirifer yassensis* Limestone Member, Taemas Formation; Emsian. Scale bars 5 mm.

Discussion. *Johnsonetes culleni* and *J. australis* are very similar. Apart from their similar size and shape, they share a tendency to develop a weak ventral sulcus, robust oblique hinge spines, and a prominent sometimes posteromedially furrowed notothyrial platform. These similarities, and similar age, have led some authors (e.g., Brock & Talent, 1993: 236) to consider them synonymous.

When erecting *Johnsonetes culleni*, Dun (1904) separated it from *J. australis* on three features: its more convex ventral valve, coarser and fewer ribs, and less marked flattening towards the cardinal angles. My observations tend to support the first, but not strongly—Ds/Ls is ≥ 0.3 in *J. australis*, 0.35–0.5 in *J. culleni*. The third difference also is apparent, but not reliable, as it depends on the size of the alae in *J. culleni*. However, the size and number of ribs is very similar in the two forms.

Chapman (in Dun, 1904) compared specimens of *J. culleni* with McCoy's types of *J. australis*, and considered the former were relatively longer (not supported herein), with a ventral valve more convex umbonally but less convex distally (not clearly demonstrable), with a tendency towards bifurcation of the ribs (uncommon in both, a little more frequent in *J. culleni*), with longer hinge spines (not clearly demonstrable), and were of greater size (incorrect).

Gill (1950) and Talent (1956) briefly re-described *J. australis* on the basis of non-type specimens from Buchan, but made no comparisons. Chatterton (1973) assigned both species to *Protochonetes*, recognised their similarity, and suggested the possibility of synonymy. He considered that *J. australis* differed from *J. culleni* in having anderidia raised on ridges, and having longer and more prominent continuations of the inner socket ridges. I can confirm both of these differences.

To all the above, I would add two things. The ventral interarea is flat in *J. australis*, weakly concave in *J. culleni*. Secondly, there is a significant difference in protegular development, which also most clearly established the junior synonymy of *Chonetes teicherti* with *J. australis* (see above). In *J. australis* both dorsal and ventral protegular structures are prominent, the ventral protegulum bearing only growth lines and the median costa (the other costae arising at its margin); in *J. culleni* the protegular structures are obscure, and all the costae radiate from the beaks.

Johnsonetes latus (Chatterton, 1973) is almost indistinguishable from *J. culleni* internally; it differs only in its smaller maximum size, more transverse outline with the greatest width always at the hinge line, and fewer more widely spaced hinge spines. Chatterton thought the two formed an evolutionary sequence within *Protochonetes*. I can confirm, from traces of spine bases preserved on a few of his generally coarsely silicified specimens, his comment (p. 75) that (using Racheboeuf's terminology) the absence of spine 1' is shared by *Johnsonetes latus* and *J. culleni*—one of the factors leading to Chatterton's suggested phylogenetic relationship between the two. *?Devonochonetes* sp. 2 Lenz & Johnson, 1985, herein tentatively assigned to *Johnsonetes*, is even smaller than *J. latus*, and significantly more finely ornamented.

Johnsonetes latus (Chatterton, 1973)

Protochonetes latus Chatterton, 1973: 73–76, pl. 17, figs. 3–24.
Johnsonetes latus.–Racheboeuf, 1987: 7–9.

Type material. HOLOTYPE ANU 18948, a silicified shell from Chatterton's locality A, on the east side of a creek flowing south into Burrinjuck Reservoir about 3 km south of Good Hope, west of Yass, NSW (34°57'14"S 148°48'55"E); figured Chatterton (1973), pl. 17, figs. 18–20. PARATYPES ANU 18949a–k, CPC 10563–65; it is not clear whether these specimens (from the Warroo Limestone Member) are from the vicinity of the type locality only, or include specimens from Chatterton's locality Cyrillic-D, a little to the north.

Stratigraphic distribution. Upper *Receptaculites* Limestone Member and lower Warroo Limestone Member, Taemas Formation, Canberra-Yass Shelf, southeastern New South Wales.

Age. Emsian (*perbonus-gronbergi* Zone), Early Devonian.

Diagnosis. Small, transverse, moderately convex, costellate species of *Johnsonetes* with distinct triangular alae, few hinge spines, deep inter-rib furrows, distinct notothyrial platform fused to strong anderidia and prominent median septum.

Description. Shell small (Ls to 10 mm, Ws to16 mm), transverse (Ls/Ws about 0.6) with greatest width at hinge line, strongly concavo-convex (Ds/Ls about 0.6), slightly less convex posterolaterally. Outline subtriangular to subtrapeziform, cardinal angles acute, slightly extended as ears. Ventral umbo broad, beak low; interarea gently concave, low, weakly apsacline to orthocline, divided by wide delthyrium with narrow arcuate pseudodeltidium. Dorsal umbo almost flat, protegular and lateral nodes distinct only in early growth stages; interarea very low, anacline; notothyrium almost filled by chilidial plates and low, wide, quadrilobed myophore. Ornament finely costellate (about 10–13 in 5 mm at 5 mm radius), increase mainly by bifurcation on ventral valve, intercalation on dorsal. Ribs rounded, separated by deep, narrow furrows. Valve interiors strongly corrugated by external ribs.

Hinge spines widely separated, asymmetrically developed, spine 1' absent, with up to three each side of umbo. Spine 1 very close to axis, gently cyrtomorph intraverse; remainder steeply oblique, obliquity increasing outwards (α apparently no less than 75°).

Ventral interior with broad triangular teeth extending only moderately beyond corners of delthyrium, and without supporting plates. Median septum short, initially thickened, tapering forward, and highest a short distance in front of beak, generally dying out by Ls/4. Muscle field flabellate, impressed posterolaterally; adductor scars sometimes clearly differentiated, and then small, ovate, separated by median septum, and surrounded by diductor scars. Valve floor papillose, the papillae elongate and aligned beneath inter-rib furrows.

Notothyrial platform prominent. Cardinal process large, wide, projecting posteriorly, bilobed, supported by robust, straight inner socket ridges overhanging deep sockets; ridges diverge forward at about 120–130°, lateral to sockets becoming lower and broadening rearwards. Ridges form straight posterior margins to distinct visceral cavity. Prominent, tapering, median septum extends forward from notothyrial platform to about three quarters of valve length. Anderidia also prominent, straight, fused to junction of inner socket ridges and notothyrial platform, diverge forward at about 50°, extend to about valve midlength. Vascula media occur as narrow grooves flanking median septum beyond midlength. Valve floor with large elongate papillae radially aligned below inter-rib furrows, and only prominent outside visceral cavity.

Comparison. The type species *J. filistriata* (Walcott) is of similar size, but is less convex, can have a shallow ventral sulcus, and is subquadrate in outline; the hinge spines are upright, and on the ventral valve the ribs, which are finer than in *J. latus*, appear to radiate from a distinct protegular area on which there is often only the median capilla. Internally, *J. latus* differs in its stronger anderidia, prominent dorsal median septum continuous with a distinct notothyrial platform, and less strongly bilobed cardinal process. Of the two species from the Emsian of the Canadian Arctic described by Racheboeuf (1987), *J. arcticus* is larger and less transverse with a more rounded outline, somewhat more finely costellate ornament, smaller cardinal process, narrower dorsal median septum, and less divergent anderidia. The other, *J. ellesmerensis*, is significantly smaller and less convex, may develop a weak ventral sulcus, and has less robust dorsal internal structures. For comparison with the other Australian species, see under *J. culleni*.

Johnsonetes? sp.

?*Devonochonetes* sp. 2 Lenz & Johnson, 1985: 59, pl. 16, figs. 5, 9–12, 14.

Material. AM F64788–92, from 549 m above the base of the Garra Formation in the composite section of Lenz & Johnson (1985: 38–39) south of Wellington Caves, near Wellington, NSW. Recorded by the authors from between 512 and 830 m above the base of the formation.

Stratigraphic distribution. Garra Formation, Molong High, central New South Wales.

Age. Probably *Eognathus sulcatus* Zone (see Lenz & Johnson, 1985, text-fig. 4), early Pragian, Early Devonian.

Description. Shell small (Ls to 6 mm, Ws to 10 mm), moderately concavo-convex, subovate to semicircular with maximum width towards midlength. Surface finely costellate (28 in 5 mm at 5 mm radius in F64791); ribs rounded, increasing by bifurcation and intercalation. Median rib not enlarged. Ventral umbo low; interarea low, apsacline; delthyrium small, with narrow pseudodeltidium apically arched over top of median septum. Dorsal interarea linear.

Hinge spines few, robust, apparently upright, probably orthomorph; insertion asymmetric. Ventral interior with short, strong, proximally high median septum; teeth short but wide, unsupported. Ventral muscle field weakly impressed posteriorly, otherwise obscure. Valve floor densely papillose, papillae radially aligned below inter-rib furrows.

Dorsal interior with low, wide, posteriorly directed cardinal process arising from distinct notothyrial platform. Platform fused to strong, widely divergent inner socket ridges whose distal ends are low and broad; outer socket ridges narrow. Median septum medium to long (*contra* Lenz & Johnson—see their pl. 16, fig. 5), low, extending forward from notothyrial platform, can extend beyond midlength. Anderidia low, arise at junction of inner socket ridges and notothyrial platform, diverge at about 50°, reach about a quarter of valve length

Discussion. Lenz & Johnson gave a very brief description of this form. That above is based on their illustrated specimens. I disagree with the authors that this species could possibly be one end-member of a variable species also including their ?*Devonochonetes* sp. 1. The ornament is significantly finer, the bases of the hinge spines are upright rather than oblique, there is an arched pseudodeltidium, a bilobed rather than trilobed myophore, better developed dorsal median septum, and more widely divergent anderidia.

The overall morphology is strophochonetine. The asymmetrical positioning of the hinge spines, clearly visible in all the figured ventral valves, suggests either *Johnsonetes* or the similarly finely costellate *Novellinetes* Havlíček & Racheboeuf, 1979. The prominent notothyrial platform, wide cardinal process, well-developed dorsal median septum and poorly impressed ventral muscle field preclude the latter, and strongly resemble the same structures in *J. australis* and *J. culleni*. This is a smaller and more finely ornamented species than those, but I think it probable that it is an early representative of the group. Racheboeuf (1998: 41) assigned the species to *Johnsonetes*, but as it is not yet possible to demonstrate that spine 1' is consistently absent (although it does look likely), that assignment is here considered as tentative.

Asymmetrochonetes Smith, 1980

Type species. *Asymmetrochonetes spinalonga* Smith, 1980: 49. Lochkovian, Canadian Arctic Archipelago.

Diagnosis. "Shell small with variably developed median enlarged costa; orthomorph perpendicular spines on right side of pedicle valve only, very rarely on left side only; inner socket ridges, median septum and anderidia faintly developed but present." (Racheboeuf, 1998: 39).

Remarks. Lenz & Johnson (1985: 59) considered *Philippotia* Racheboeuf, 1982 (= *Chlupacina* Havlíček & Racheboeuf, 1979), to be a junior synonym of *Asymmetrochonetes* Smith, 1980, both of which have hinge spines to one side only, on the basis (*contra* Smith, 1980) that the median costa is enlarged in both. Racheboeuf (1990: 167) disagreed with that synonymy, because *Asymmetrochonetes* has a faint dorsal median septum in place of the cardinal process pit developed in *Chlupacina*. From the diagnoses in Racheboeuf (1998), the two also differ in the development of the anderidia (weakly developed in *Asymmetrochonetes*, distinct but short, and widely divergent, in *Chlupacina*) and inner socket ridges (only weakly developed in *Asymmetrochonetes*).

Asymmetrochonetes? planata Lenz & Johnson, 1985

Asymmetrochonetes planata Lenz & Johnson, 1985: 59–60, pl. 16, figs. 13, 15–24.

Type material. HOLOTYPE AM F64796 (Lenz & Johnson, pl. 16, figs. 17, 21) and PARATYPES AM F64793–95, 64797–99, from 610, 553, 608 and 717 m above the base of the Garra Formation in the composite section of Lenz & Johnson (1985: 38–39) south of Wellington Caves near Wellington, New South Wales.

Stratigraphic distribution. Between 514 and 717 m (616 m in Lenz & Johnson's text-fig. 4) above the base of the Garra Formation, Molong High, central New South Wales.

Age. Probably *Eognathus sulcatus* Zone, early Pragian, Early Devonian.

Diagnosis. Small weakly biconvex to plano-convex strophochonetine with only two spines on left side of hinge, none on right; ornament finely costellate, median costa little to slightly enlarged; ventral valve with arched pseudodeltidium, short median septum; dorsal valve with short, straight inner socket ridges, short detached anderidia and median septum, small cardinal process pit.

Description. Shell small (Ls to 7 mm, Ws to 11 mm for figured specimens), gently biconvex through planoconvex to occasionally slightly resupinate, subovate to semicircular, greatest width at hinge. Surface finely costellate (about 25 capillae in 5 mm at 5 mm radius), median capilla often slightly enlarged; capillae rounded, radiating from umbo; increase by bifurcation. Ventral umbo very low, interarea low, apsacline; pseudodeltidium strongly arched, arcuate. Dorsal umbo flat, interarea linear, notothyrium filled by small quadrilobed myophore. Two sinuous, upright to intraverse hinge spines on left side of valve only.

Ventral interior with small triangular teeth, short (Ls/5) but strong median septum, obscure muscle field. Valve floor with low papillae aligned beneath intercapillar furrows.

Cardinal process wide, short, posteriorly directed, the lobes separated by deep but narrow furrow, and supported by short, strong, straight, widely divergent inner socket ridges. Cardinal process pit small to distinct, shallow, somewhat elongate. Anderidia short, narrow, isolated, diverge forward at 45–50°. Median septum short, low, rounded, detached from cardinal process. Adductor muscle scars small, narrow, triangular, strongly impressed between anderidia and median septum; valve floor in front of scars coarsely papillose, remainder of valve floor as in ventral valve.

Remarks. Lenz & Johnson gave only a brief description, enlarged here to allow discussion of the generic position of their species, which displays characteristics of both *Asymmetrochonetes* and *Chlupacina*. There is a short but distinct dorsal median septum (as in *Asymmetrochonetes* but not *Chlupacina*) but also a variably developed, sometimes elongate, cardinal process pit (one of the characteristics of *Chlupacina*). *Asymmetrochonetes? planata* also resembles *Chlupacina* more than *Asymmetrochonetes* in that its anderidia are distinct, short and thin, and diverge at 45–

50°, but unlike in *Chlupacina* the front margins of cardinal process and inner socket ridges do not rise nearly vertically from the valve floor. In view of this mixture of characteristics, the species is only tentatively retained in *Asymmetrochonetes*.

Protochonetinae Racheboeuf, 1998

Protochonetes Muir-Wood, 1962

Type species. *Protochonetes ludloviensis* Muir-Wood, 1962, 51. Ludlow, Welsh Borderlands.

Diagnosis. "Small to medium, plano- to concavo-convex shell; pseudodeltidium and chilidium, or chilidial plates present; median enlarged costa usually absent or weakly developed; spines symmetrically arranged, orthomorph oblique, low to high-angled; dorsal interior with median septum and weakly divergent anderidia; inner socket ridges varying from short and curved to long, narrow, parallel to hinge line." (Racheboeuf, 1998: 44).

Protochonetes* sp. cf. *minimus
(J. de C. Sowerby, 1839)

Fig. 11

Protochonetes sp. cf. *minimus*.–Strusz, 1982: 122–123, fig. 16, *cum syn.*–Strusz, 1984: 132–133, fig. 10.

Material. CPC 20420–33, 20995–21000, 21073 from three localities near Coppins Crossing on the Molonglo River, Canberra, and CPC 23781–90 from one locality west of Yarralumla, Canberra.

Stratigraphic distribution. Siltstone within the Walker Volcanics, and Yarralumla Formation, Canberra-Yass Shelf, Australian Capital Territory.

Age. Wenlock (probably Homerian) to earliest Ludlow (early Gorstian), Early to Late Silurian.

Description (summary after Strusz, 1982 and 1984). Shell small (Ws to 9 mm), thin, moderately concavo-convex, transverse, subovate to subquadrate, greatest width about midlength, cardinal angles obtuse or weakly alate. Umbones and dorsal interarea obscure; ventral interarea narrow, apsacline; delthyrium apparently open. Up to four straight or gently curved strongly oblique hinge spines on each side (α c. 40–50°). Capillate, ventral median capilla not accentuated; increase by both bifurcation and intercalation. Myophore small, quadrilobed, median groove much stronger than other two; no chilidial plates have been seen.

Teeth small, subparallel to hinge. Ventral muscle field flabellate, weakly impressed. Ventral median septum short (c. 10% Ls), fine, expanded and in some shells bifid posteriorly. Valve floor strongly reflects external ornament, but lacks obvious papillae.

Dorsal interior unknown.

Comparison. The summary description given above is included to facilitate comparisons. The generic position of Sowerby's species remains uncertain, as the dorsal interiors are still unknown; as noted elsewhere (Racheboeuf, 1976; Strusz, 1982) the greatest similarity is with *Protochonetes*. Racheboeuf (1998: 45) unequivocally refers it to that genus. There are several other small species of *Protochonetes*, but only three bear close comparison with *P.* sp. cf. *minimus*. *Protochonetes tenuistriatus* (Hall, 1860) from the late Llandovery of Nova Scotia, as re-described by Harper (1973), is a little larger, more transverse, with the greatest width forward of the hinge line, and has a longer, better developed ventral median septum. Somewhat larger again are *P. elyensis* Sheehan, 1982 (Wenlock, Nevada) and *P. harricanensis* Jin *et al.*, 1993 (late Llandovery, Arctic Canada); the former differs from *P.* sp. cf. *minimus* in being markedly elongate, strongly concavo-convex, and more finely capillate, whereas the latter is only gently concavo-convex, coarsely capillate, and has relatively robust close-set hinge spines.

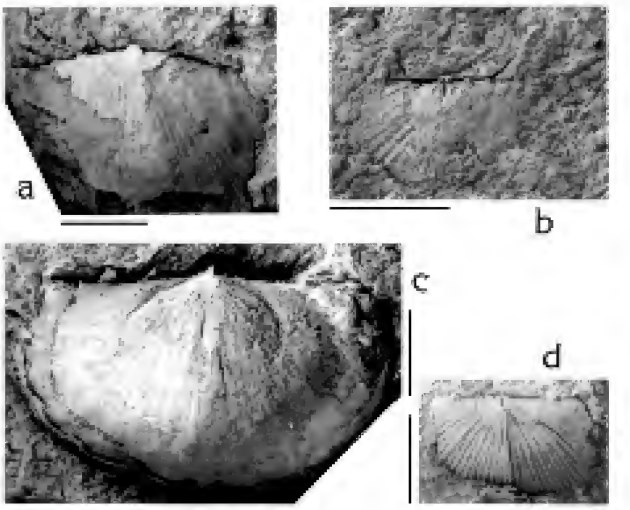

Figure 11. **a–d**: *"Protochonetes"* sp. cf. *minimus*; **a**, CPC 23781, ventral valve; **b**, CPC 23785, dorsal external mould (and hinge spines); **c**, CPC 23787, ventral internal mould; **d**, latex from ventral external mould. Yarralumla Formation (a–c) and Walker Volcanics (d); Homerian to early Gorstian. Scale bars 2 mm.

Two Australian Silurian chonetoideans which could be mistaken for *P.* sp. cf. *minimus* are *Strophochonetes melbournensis* (Chapman) and *S. kemezysi* n.sp. The former is much less convex and can have a broad sulcus anteriorly; the outline is subquadrate and gently alate, there is a prominent ventral median capilla, and the long hinge spines are usually nearly upright, mostly gently cyrtomorph. *Strophochonetes kemezysi* is closer in size and convexity, but is widest at the hinge line and has finer, generally upright or steeply oblique hinge spines; it normally has an accentuated ventral median capilla. Reasonably preserved specimens can be easily distinguished from *P.* sp. cf. *minimus* by the distinctive strophochonetine median capilla.

***Protochonetes*? sp. indet.** Strusz, 1982

Fig. 12

Protochonetes? sp. indet. Strusz, 1982: 123, fig. 17.

Material. CPC 20434; locality 101, near Coppins Crossing, Molonglo River west of Canberra.

Stratigraphic distribution. Shale within the Walker

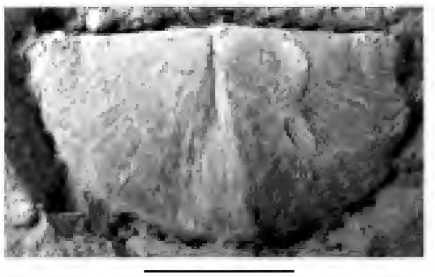

Figure 12. *Protochonetes?* sp. indet. Strusz, 1982; CPC 20434, ventral valve. Walker Volcanics; Homerian. Scale bar 5 mm.

Volcanics, Canberra-Yass Shelf, Australian Capital Territory.

Age. Homerian, late Wenlock, Early Silurian.

Discussion. The single rather poorly preserved small ventral valve tentatively assigned to *Protochonetes* by Strusz (1982), is of low convexity and semi-ovate outline, with subdued fine ribs (without accentuated median costa) which appear to be parvicostellate. There are four very oblique spine bases, but the course of the spines away from the cardinal margin is unknown. The valve is partly decorticated, revealing that the valve floor is densely papillose, with the papillae radially arranged. No other details are known.

The apparently parvicostellate ornament recalls the Chonostrophiidae, but the shell is definitely not resupinate. Overall appearance, size and proportions are close to those of *Strophochonetes kemezysi* and *S. melbournensis*. In particular, NMV P626–27 (ventral internal moulds, paralectotypes of *S. melbournensis*) show the same papillose valve floor, and the internal reflection of similarly fine ornament. Of the two, P626 has a prominent median capilla but P627 does not, which means its absence in the Canberra specimen is not by itself significant. However, the shallow angle at which the spine bases in that specimen leave the cardinal margin makes it highly unlikely that the two are synonymous, and the original assignment is left unchanged.

Parachonetinae Johnson, 1970

Parachonetes Johnson, 1966

Type species. *Chonetes macrostriata* Walcott, 1884: 126, pl. 2, fig. 13?, pl. 13, figs. 14, 14c; subsequent designation Johnson, 1966: 367. Emsian, Nevada.

Diagnosis. "Shell medium to large, strongly concavo-convex; radial rounded, irregular costae; spines orthomorph, high-angled to perpendicular and symmetrically arranged; dorsal valve interior with a wide, more or less deep cardinal process pit between the bases of the two lobes of the cardinal process; long anderidia anteriorly divergent at 35°. Posteriorly fused with the cardinal process lobes; well-developed median septum; low, ill-defined inner socket ridges anteriorly divergent at 100–130°." (Racheboeuf, 1998: 47).

Discussion. When erecting his new genus, Johnson unequivocally included only four species: the type species *Chonetes macrostriata* Walcott, 1884 from the Emsian of Nevada; *C. verneuili* Barrande, 1879 from the Early Devonian of Eurasia; and from the Early Devonian of Victoria, *C. baragwanathi* Gill, 1949, and *C.? suavis* Talent, 1963 (with the comment that these two species might be synonymous). Chatterton (1973) described two new species from the Emsian of New South Wales. Johnson (1966) suggested there were two species groups: one centred around *P. macrostriatus* and including the Victorian species, and the other comprising *P. verneuili* (Barrande).

In 1951, Gill formally recognised "... a rich gens of apparently indigenous species related to *C. robustus*, and it is proposed that in future this group is known as the *C. robustus gens*." He included in this species-group *Chonetes buchanensis, killarensis, productoidus, baragwanathi, robustus* and *cresswelli*. It was characterised as "... a group of larger, rather coarsely costellate species, with short ventral median septum, and spines set at right angles to the hinge-line. Where known, the dorsal valve has a comparatively long median septum and two accessory septa [i.e. anderidia]."

The present study has shown that only *C. cresswelli* does not belong in this "gens" (group), that the first three in the above list are subjective synonyms, and that the remaining two could well be so. All are strongly concavo-convex; coarsely and somewhat irregularly ribbed, the ribs radiating not only from the beak, but from the inner part of the cardinal margin, with which they make a large angle; have orthomorph hinge spines on either side of the beak; and the shell floor is finely and densely papillose at least marginally. Shells closest to *P. baragwanathi* and *P. robustus* are large, with a tendency to develop rounded alae, and can develop shallow ventral sulci; the ventral interarea is orthocline to anacline and sometimes twisted (as in the type species, *P. macrostriatus*), and the hinge spines are oblique (*contra* Gill). Only the absence of dorsal interiors in some species prevents final resolution of the relationships within the group, but otherwise the similarities are so great that I have no doubt all are *Parachonetes*.

I tentatively suggest adding two other species to the *robustus* group: *C. bowieae* Gill, 1945, and *C.? suavis* Talent, 1963. These species differ from those unequivocally placed in the group in being a little smaller, with little if any tendency to form alae, and no sulcus; the spines are upright in the former, unknown in the latter. Another significant difference (enough to leave some uncertainty even on generic position) is that the ribs radiate from very near the beak, so making a shallow angle with the hinge. Nevertheless the overall morphological similarities between *P.? bowieae, P.? suavis* and the *robustus* species-group are considerable.

Congeneric but not so close morphologically are *P. konincki* and *P. flemingi* Chatterton, 1973, and possibly *P.? spooneri* (Talent, 1956). All are large and coarsely ribbed, but have consistently anacline ventral interareas, alae absent or small and angular, no sulci, more oblique hinge spines (at least in Chatterton's species), and lower ventral median septum.

Table 1 compares ventral valve structures in all these species, while the relationship between length and width is plotted for most of them in Figs. 14 and 17. Of those most likely to be conspecific (i.e. *"Chonetes" baragwanathi, "C." killarensis, "C." productoida, "C." robusta* and *"C." buchanensis*), the generic position is firmly established only in *P. baragwanathi*, in which both valves are known. The incompletely known taxa which I nevertheless consider to

be very probably conspecific are questionably included in its synonymy list to highlight that situation, but are then treated separately because none has been adequately described to current standards. Should additional specimens be found which firmly establish that only one species is involved, then for that species the earliest name, that of *"Chonetes" robusta* Chapman, 1903, will take priority.

Parachonetes baragwanathi (Gill, 1949)

Figs. 13, 14

? *Chonetes robusta* Chapman, 1903: 76–77, pl. 12, fig. 8; Gill, 1945: 134; Gill, 1949: 109, pl. 3, figs. 15, 17; Boucot & Harper, 1968: 151.
? *Chonetes (Chonetes) killarensis* Gill, 1945: 140–141, pl. 8, fig. 14; Boucot & Harper, 1968: 151.
? *Chonetes (Chonetes) productoida* Gill, 1945: 141–142, pl. 8, figs. 3, 7, 12.
Chonetes baragwanathi Gill, 1949: 107–109, pl. 3, figs. 10, 14, 16, 20, 23.
Chonetes? baragwanathi.–Talent, 1963: 68, pl. 36, figs. 1–21, pl. 37, figs. 1–7.
? *Chonetes?* sp. B Talent, 1963: 69, pl. 41, fig. 7.
Parachonetes baragwanathi.–Johnson, 1966: 366.
? *Chonetes buchanensis* Gill, 1951: 68–70, pl. 3, figs. 17, 20; Talent, 1956: 45.

Type material. HOLOTYPE NMV P52367 (Fig. 13a; formerly GSV 27219), a posteriorly damaged distorted ventral internal mould from NMV PL565 (Gill's locality 23), Sandy's Creek, Tabberabbera area; this is on a slope 250 m southeast of Warrigal Bend, Parish of Nungatta, East Gippsland; figured Gill (1949, pl. 3, figs. 7, 14, 16); Kilgower Member, Tabberabbera Formation. PARATYPE NMV P31927 (GSV 27214A, B), a distorted dorsal internal mould from locality NMV PL564 (= G22), Sandy's Creek; figured Gill (1949, pl. 3, fig. 10).

Other material. *Figured or cited by Gill (1949).* NMV P31930 (GSV 27180, 27183; Gill, 1949, pl. 3, fig. 23) + counterpart 52382 (locality NMV PL564 = G22), and topotype P52380 (GSV 27200).

Figured by Talent, 1963. NMV P47585–92 (ex GSV 56587, 56505, 56259, 56379, 56625, 56380a, 56380b, 56053b), 60863–70 (ex GSV 56565a, 56353, 56598, 56274, 56368, 56612, 56056c, 56606), 60938 (GSV 55882), 60939 (GSV 55878), 74166 (GSV 56325), 74167 (GSV 56251) from several Tabberabbera localities. Also possibly NMV P60908 (formerly GSV 57150), from Talent's locality 46, hillside southwest of left branch, Dead Bull Creek, Parish of Nungatta, Gippsland, figured Talent (1963, pl. 41, fig. 7).

Stratigraphic distribution. Kilgower and possibly Dead Bull Members, Tabberabbera Formation, Mitchell Syncline, eastern Victoria.

Age. Pragian, Early Devonian.

Diagnosis. Large coarsely and irregularly costellate species of *Parachonetes*, the lateral costae radiating from the hinge

Table 1. Comparison of ventral valve structures for Australian species of *Parachonetes*. The table is arranged with members of the *"robustus"* group in columns 1–3, possible members of the group in columns 4–5, and species distant from that group in the remainder. Structures common to all and so not shown in the table are: profile strongly concavo-convex; ornament coarsely costellate; ribs rather wavy and radiating from beak and nearby cardinal margin; valve floor finely and densely papillose marginally; teeth triangular, small but prominent, slightly to moderately elongate parallel to hinge.

	baragwanathi	*robustus*	*buchanensis*	*bowieae*	*suavis*[1]	*spooneri*	*konincki*	*flemingi*
size	large	medium	large	medium	medium	large	very large	large
alae	absent, or large, rounded	absent, or moderate, rounded	large, rounded	none? or weak	absent or weak	absent	absent	weak
sulcus	absent, or broad, shallow	absent, or shallow	absent or weak	absent	absent	absent	absent	absent
interarea	orthocline to anacline, usually curved	orthocline (approx.)	orthocline	orthocline	orthocline	anacline, curved	anacline	anacline
spines/side	oblique up to 7	oblique, up to 5	oblique, ≥4	upright, 4	?	?	oblique, c. 5–6	oblique, c. 5–6
ribs/5 mm	8–9 (max. 14)	10–11 (max. 13)	7–12	15 (type)	11–13	c. 8	5–7	7–10
med. septum	short, thin, fairly low	to Ls/3; thin, high posteriorly	short, thin?	Ls/4; thin, high posteriorly	to Ls/4; thin, high posteriorly	?	c. Ls/5; low	<Ls/3; low, detached
age	Pragian	Lochkovian to Pragian	Emsian	Pragian	Pragian	Emsian	Emsian	Emsian

[1]The one ventral internal mould of *P.? suavis* is not nearly as convex as that of *P.? bowieae*, but ornament, median septum and teeth are comparable.

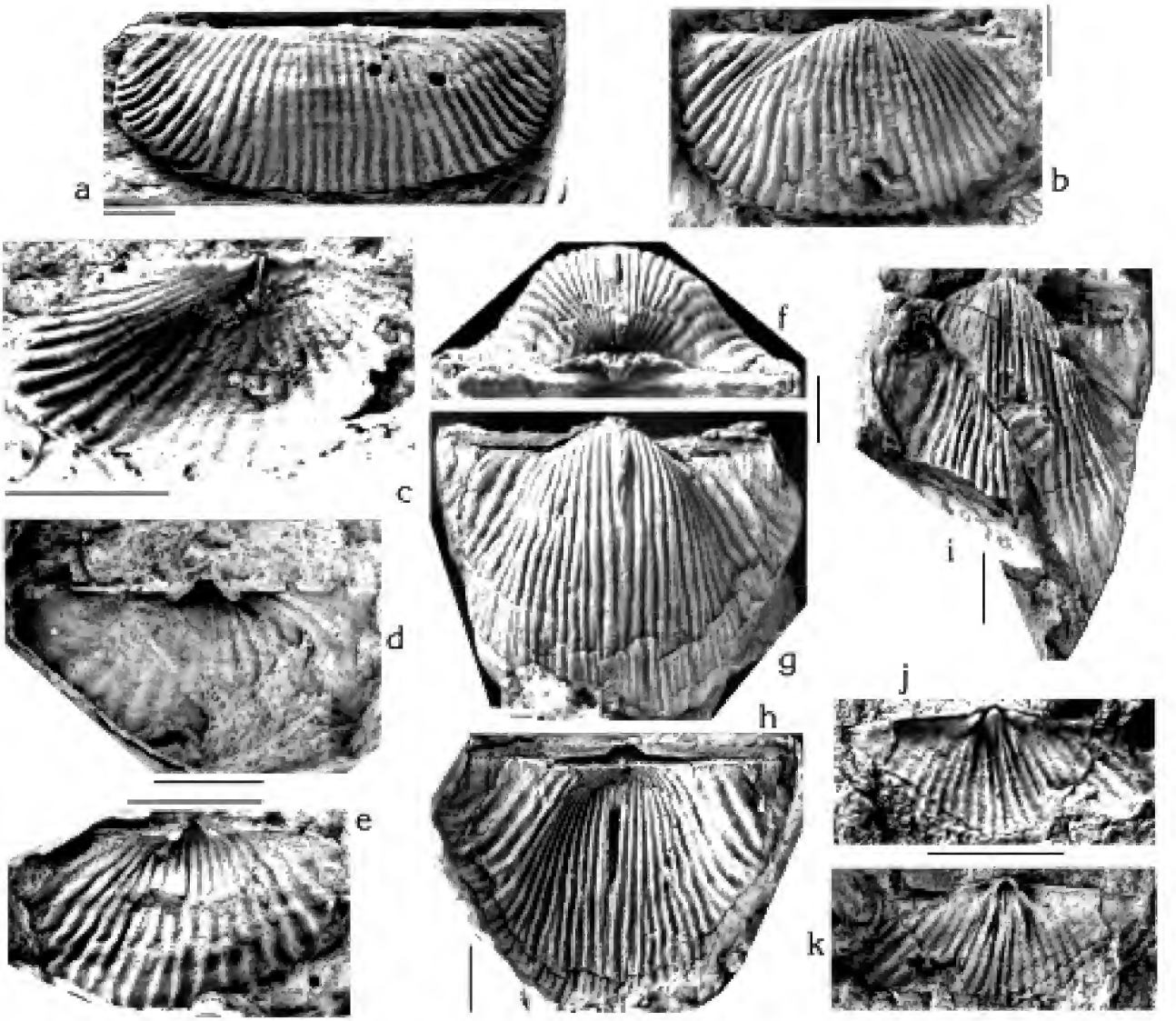

Figure 13. **a–c**, **e–k**: *Parachonetes baragwanathi*; **a**, holotype NMV P52367, longitudinally compressed ventral internal mould; **b**, NMV P47592, ventral internal mould; **c**, NMV P60870, latex from ventral internal mould; **e**, NMV P47585, latex from ventral internal mould; **f–h**, NMV P47590, dorsal external mould (also showing ventral interarea) in posterior and ventral aspects, and latex replica in posterodorsal aspect showing interareas and myophore; **i**, NMV P60869, damaged and laterally compressed ventral internal mould; **j,k**, NMV P60938, incomplete dorsal internal mould and latex replica. Kilgower Member, Tabberabbera Formation; Pragian. **d**: ? *P. baragwanathi*, NMV P60908, latex from incomplete distorted ventral internal mould. Dead Bull Member, Tabberabbera Formation; Pragian. Scale bars 2 mm (c,d) and 5 mm.

line; commonly with rounded alae and broad, shallow ventral sulcus; hinge spines robust, oblique; ventral median septum short, thin, teeth small but strong; dorsal median septum low, relatively short; cardinal process high, arched over prominent cardinal process pit, continuous with straight, robust inner socket ridges; straight anderidia fused to inner socket ridges, diverge at about 25°, with small spines at highest points.

Description. Shell large (Ls over 20 mm, Ws over 30 mm), strongly concavo-convex (Ls/Ds 2.4–2.6), moderately elongate (Ls/Ws about 0.6–0.8). More or less prominent rounded alae and broad shallow ventral sulcus commonly present; hinge width equal to or slightly less than maximum width, which is usually in front of hinge line. Ventral beak incurved, prominent; interarea usually curved, orthocline to anacline. Delthyrium open, apical angle about 90°, with bounding ridges in some specimens. Dorsal interarea ⅓–½ height of ventral interarea, hypercline. Myophore quadrilobate. Chilidial plates very narrow in small shells, in larger shells prominent, almost meeting medially, and covering proximal third of cardinal process. Hinge spines orthomorph or gently geniculate, oblique (*contra* Gill, 1949), α apparently varying from 75° to as low as 40°; spines symmetrically placed. Shell thin.

Radial ornament costellate; ribs strong, coarse, rounded and often sinuous or irregular (generally 8 or 9 in 5 mm at 5 mm radius; 10–16 per cm anteromedially), separated by narrower furrows; 50 or more ribs marginally in large shells. Details of increase on ventral valves obscure, but bifurcation

occurs, most commonly anterolaterally. On dorsal valve, increase tends to be by intercalation medially, bifurcation laterally (most distinctly on alae).

Ventral interior with variably developed median septum, mostly thin, short, and not particularly high. Only reasonably well preserved interior, NMV P47585, shows what appears to be an ovate adductor field with weak bounding ridge, extending beyond median septum; generally, however, internal reflection of ribs strong enough to obscure traces of musculature. Papillae numerous, small, most abundant laterally and marginally, without obvious regular arrangement. Teeth small but strong, triangular in section, slightly elongate parallel to hinge, rounded distally.

Dorsal median septum low, short in one of two available dorsal interiors, longer and expanded anteriorly in other. Prominent anderidia diverge at about 25°, in one specimen showing what appear to be very short spines at their highest points (in front of their midlength). Outer socket ridges narrow but distinct. Robust inner socket ridges, fused to anderidia posteriorly, merge with short, high, inwardly bifid cardinal process arched over distinct cardinal process pit. Small papillae, as in ventral valve.

Discussion. The specimens are all strongly distorted and often incomplete, but do include internal and external moulds of both valves. As recognised by Johnson (1966), the overall appearance and details of the cardinalia are typical of *Parachonetes*. Johnson suggested that *Chonetes? suavis* Talent, 1963, may be a synonym of *P. baragwanathi*, with the only difference being the latter's "split dorsal septum". Both are large, coarsely costellate, and come from the Kilgower Member, but Talent's species differs in having a much longer and more robust dorsal median septum (which can develop a median groove posteriorly), anteriorly geniculate anderidia which posteriorly diverge at about twice the angle found in *P. baragwanathi*, a more prominent cardinal process, and more robust inner socket ridges whose distal ends are turned laterally, almost parallel to the hinge line.

The small incomplete ventral internal mould described as *Chonetes?* sp. B by Talent (1963), while flattened and incomplete, is close to *P. baragwanathi* in its short, fine, posteriorly slightly enlarged median septum, robust triangular teeth, and robust spine bases—compare NMV P60870, figured by Talent (1963, pl. 37, fig. 7). I tentatively place the two forms in synonymy.

Parachonetes robustus (Chapman, 1903)

Figs. 14, 15a–o

Chonetes robusta Chapman, 1903: 76–77, pl. 12, fig. 8; Gill, 1945: 134; Gill, 1949: 109, pl. 3, figs. 15, 17; Boucot & Harper, 1968: 151.

Chonetes (Chonetes) killarensis Gill, 1945: 140–141, pl. 8, fig. 14; Boucot & Harper, 1968: 151.

Chonetes (Chonetes) productoida Gill, 1945: 141–142, pl. 8, figs. 3, 7, 12.

Type material. HOLOTYPE NMV P1417 (Fig. 15a–c), a damaged steinkern (part ventral internal mould, part dorsal external mould) from NMV PL1803, "Hughes Quarry (north of Lilydale)". This is at the summit of a low hill near the middle of the block of land bounded by Edward, Coldstream West and Victoria Roads, Chirnside Park, north of Melbourne; Christmas Hills 1:25,000 sheet 7922–1–3, grid reference 528.239.

Type material of *"C." productoida* Gill. HOLOTYPE NMV P14520 (Fig. 15d–f), a rather worn and distorted ventral internal mould, and PARATYPE P14521 (Fig. 15g,h), a ventral internal mould. Both are from NMV PL1803, the type locality of *C. robustus*.

Type material of *"C." killarensis* Gill. HOLOTYPE,: NMV P123067 (Fig. 15k–m; formerly MUGD 1915), a ventral internal mould from NMV PL1834, "Syme's Tunnel", Healesville district; Healesville 1:100,000 sheet 8022, grid reference 684199.

Other material. Topotypes NMV P1418A & B (adjacent valves); also P25569 (NMV PL1824, Victoria Road Cutting), 33103 (NMV PL1813, Hull Road, Mooroolbark), 33107 (NMV PL1834), 80125 (W of Hull Road), 142029 and 142031–32 (Kilsyth).

Stratigraphic distribution. Humevale Formation, Melbourne Trough, central Victoria.

Age. Lochkovian to Pragian, Early Devonian.

Diagnosis. *Parachonetes* close to *P. baragwanathi*, differing in its smaller size, and in having its greatest width towards midlength even in alate shells.

Description. Shell medium-sized; greatest observed Ls 17.7 mm (corresponding Ws 21.2 mm) in holotype of *Chonetes killarensis*. Outline rather elongate, with Ls/Ws varying between 0.66 and c. 0.85 (8 specimens); some large shells have rounded alae. Shallow ventral sulcus. Greatest width usually in front of hinge, even in alate shells, in some lying as far forward as about 0.4Ls, but Wh little less than Ws. Longitudinal profile strongly concavo-convex (Ls/Ds 1.9–4.3, for five good specimens 2.1–3.0). Ventral beak prominent, incurved; interarea orthocline or nearly so (may be anacline or apsacline), and flat. Delthyrium rather narrow, apical angle 70–90°; apparently open. Dorsal interarea very narrow, attitude uncertain; chilidium and myophore obscure. Up to five symmetrically placed spines seen to each side of umbo, of oblique orthomorph type and apparently weakly geniculate (see Racheboeuf, 1981), α c. 70°, but spines mostly not preserved. Shell thin.

Radial ornament coarsely costellate, ribs strong, rounded and often slightly sinuous (5–7 in 5 mm anteromedially, may be wider but lower on alae); intervening furrows as wide, also rounded. Twenty-six to thirty-two costae, lateral costae originating along cardinal margin (and radial to a point posterior to the ventral beak). Ribs increase by bifurcation, mostly towards margin of larger shells, but with no clear pattern and increase not extensive; up to 42 ribs marginally. Growth lines generally obscure.

Ventral interior with relatively short median septum (up to a third of valve length but generally shorter), thin and high posteriorly, falling fairly steeply towards valve floor, but not significantly prolonged as myophragm. Teeth small but relatively strong, triangular in section, slightly elongate

parallel to hinge, rounded distally. Muscle field obscured by strong reflection of external ornament, but visceral cavity generally impressed. Papillae low, most abundant marginally, otherwise show no clear organisation.

Dorsal interior not known.

Discussion. Preservation, as moulds in mudstone, is generally mediocre; consequently quoted dimensions in many cases are only best estimates, and the total number of hinge spines is rarely visible. The ventral valves and dorsal exterior of *P. robustus* are almost indistinguishable from those of *P. baragwanathi*, despite the distortion the latter have suffered, and I am confident in referring the former to *Parachonetes*. *Parachonetes baragwanathi* differs in its moderately greater size, and in features probably related to that, such as greater convexity and number of spines, and in the predominantly curved anacline interarea. As already noted, it is therefore very likely that the two forms are synonymous.

Only four specimens are known from the type locality, of which two comprise the total material for *"Chonetes" productoida* (Fig. 15d–h), and the others are the holotype

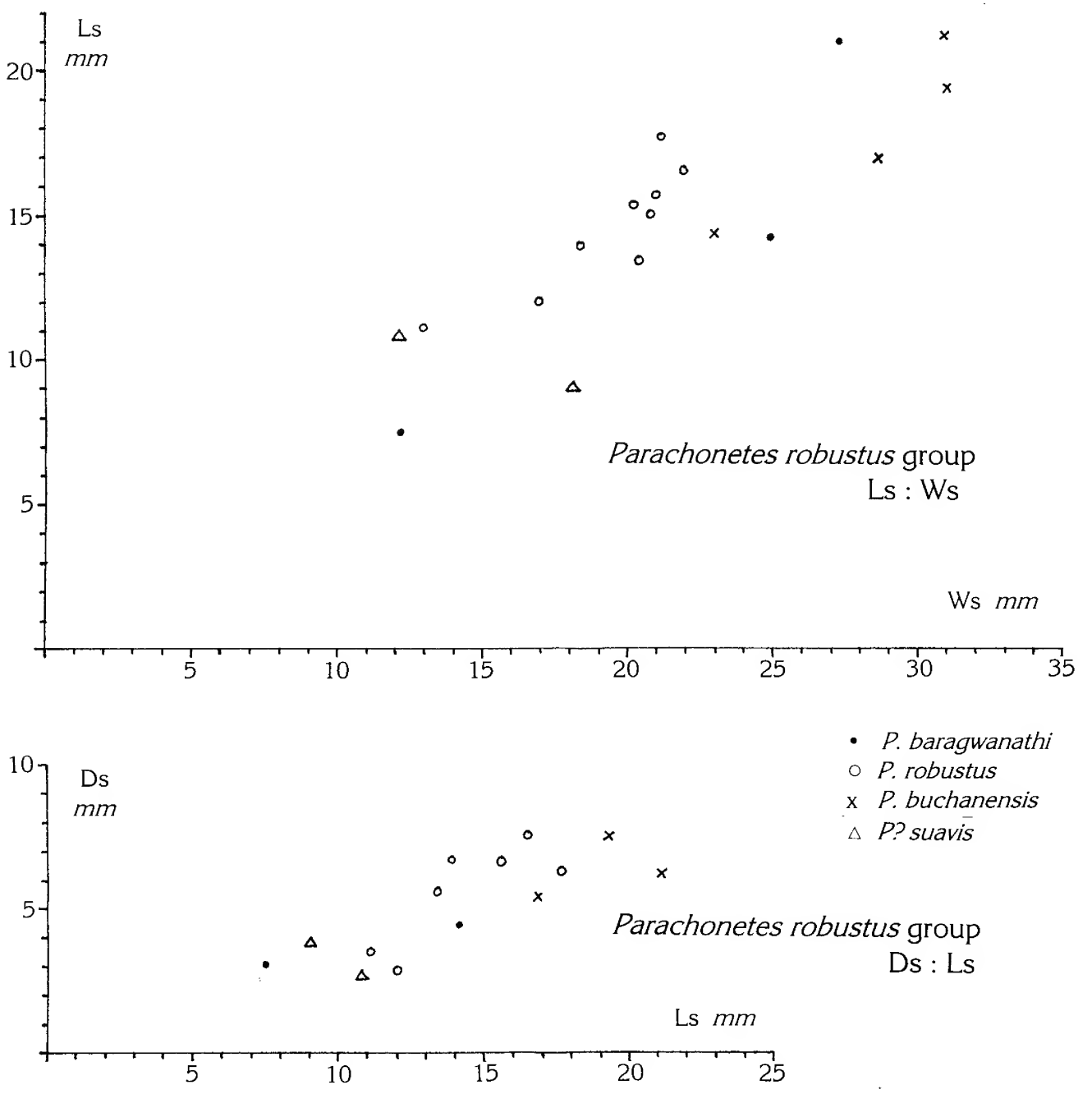

Figure 14. Scatter diagrams of length against width and depth against length for measurable species of the *Parachonetes robustus* group.

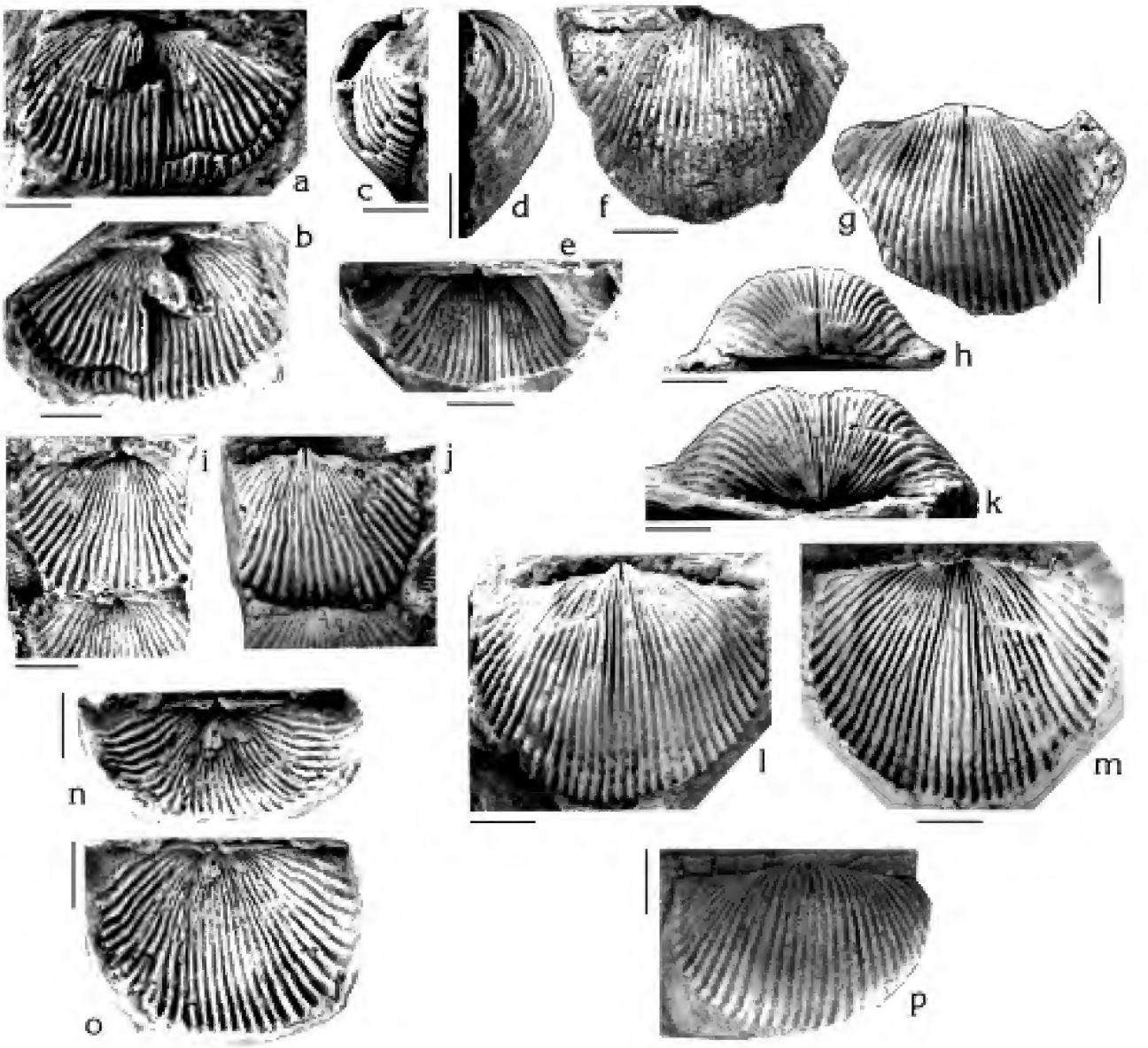

Figure 15. **a–o**: *Parachonetes robustus*; **a–c**, holotype NMV P1417, damaged internal mould in ventral and lateral aspects (a, c) and latex replica in dorsal aspect (b); **d–f**, holotype of *Chonetes productoida*, NMV P14520, ventral internal mould in lateral and ventral aspects (d, f) and latex replica in posterodorsal aspect; **g,h**, paratype of *Chonetes productoida*, NMV P14521, ventral internal mould in ventral and posterior aspects; **i,j**, topotypes NMV P1418A (above) NMV P1418B (below), latex replica and ventral internal moulds; **k–m**, holotype of *Chonetes killarensis*, NMV P123067, ventral internal mould in posterior and ventral aspects (k,l) and latex replica (m); **n,o**, NMV P80125, latex from ventral internal mould in posterodorsal and dorsal aspects. Humevale Formation; Lochkovian to Pragian. Scale bars 5 mm. **p**: *Parachonetes?* sp. cf. *robustus*; NMV P33109, ventral internal mould. Humevale Formation; Lochkovian. Scale bar 5 mm.

(Fig. 15a–c) and a topotype (Fig. 15i,j) of *"C." robustus*. The former differ from all specimens previously assigned to *"Chonetes" robustus* in being somewhat larger, prominently alate and a little more convex, and in having slightly anacline interareas. Gill (1945: 141–2) considered *productoida* differed significantly in having a recurved beak and high umbonal area, but comparison of the holotypes shows no difference in umbonal convexity, and only slight difference in the attitude of the interarea (either side of orthocline). The two specimens appear to me to lie within the range of variability of shells assigned to *P. robustus*, and so I consider the species to be synonymous.

The one specimen of *"Chonetes" killarensis* (Fig. 15k–m) lacks alae, as do some *robustus*, but is otherwise identical with the latter; it is relatively well preserved, and shows 5 oblique spines (α c. 70°) to either side of the umbo. The currently available material does not support Gill's (1945) contention that the main difference lies in the hinge spines: short, fine and sinuous in *killarensis*, long, strong and straight in *robustus*.

Parachonetes? sp. cf. *robustus* (Chapman, 1903)

Fig. 15p

Material. NMV P33109, a ventral internal mould from PL1802, "Wilson's", an excavation in Albert Hill Road about 400 m east of the intersection with Victoria Road, Lilydale.

Stratigraphic distribution. Humevale Formation (in pale khaki mudstone), Melbourne Trough, central Victoria.

Age. Lochkovian, Early Devonian.

Description. The valve is of moderate size (Ls 11.5 mm, Ws 18.6 mm), strongly convex (Ds/Ls 0.47), ovate in outline and slightly alate. Greatest width separated from equally wide hinge margin by shallow re-entrants, such that cardinal angles are acute (c. 70°), alae small. Shallow V-shaped sulcus. Interarea low, orthocline; delthyrium wide; small apical pseudodeltidium. Probably four spines each side; bases oblique, but spines for most of their course upright, straight or possibly gently curved.

Radial ornament of costellate ribs strong, rounded, spaced medially eight in 5 mm at 5 mm radius; ribs radiate from inner part of hinge, rare bifurcation bringing number to 33 marginally. Ribs straight medially, slightly sinuous laterally, weak towards alae.

Ventral median septum short (c. ⅛ Ls), strong and high, not prolonged as myophore. Valve floor very finely papillose, muscle field obscure. Teeth robust, supported by very short dental plates.

Dorsal valve unknown.

Comparison. The deep convexity, strong ribs, shallow but distinct sulcus, basally oblique but distally more nearly upright spines, orthocline interarea and short strong median septum make this single specimen closely comparable with *Parachonetes robustus* and, to a lesser extent, *P. baragwanathi*. It differs in having small sharp alae and possibly gently cyrtomorph hinge spines, and in having short dental plates. *Parachonetes flemingi* and *P. konincki* have short dental plates, but their hinge spines are more oblique, and they lack ventral sulci.

Parachonetes buchanensis (Gill, 1951)

Figs. 14, 16

Chonetes buchanensis Gill, 1951: 68–70, pl. 3, figs. 17, 20; Talent, 1956: 45.

Type material. HOLOTYPE NMV P47628 (Fig. 16a–c; formerly GSV 48690), a partly decorticated and somewhat damaged ventral valve in limestone "from the big eastward bend in the Gelantipy Road, ½ mile south of Murrindal State School", Buchan district, East Gippsland; figured Gill (1951, pl. 3, fig. 17); Murrindal Limestone. PARATYPE NMV P47627 (GSV 48824) from the same locality, a damaged ventral valve figured Gill (1951, pl. 3, fig. 20).

Other material. Figured specimen NMV P34621 (GSV 48825B) a damaged ventral valve from the ridge east of Rocky Camp, 65.5 m above the Buchan Caves Limestone; figured Gill (1951, text-fig. 8). Topotypes NMV P79735–41 (fragmentary specimens from the same limestone block, GSV 48690, as the holotype), and 80100 (GSV 48691; a partly decorticated ventral valve).

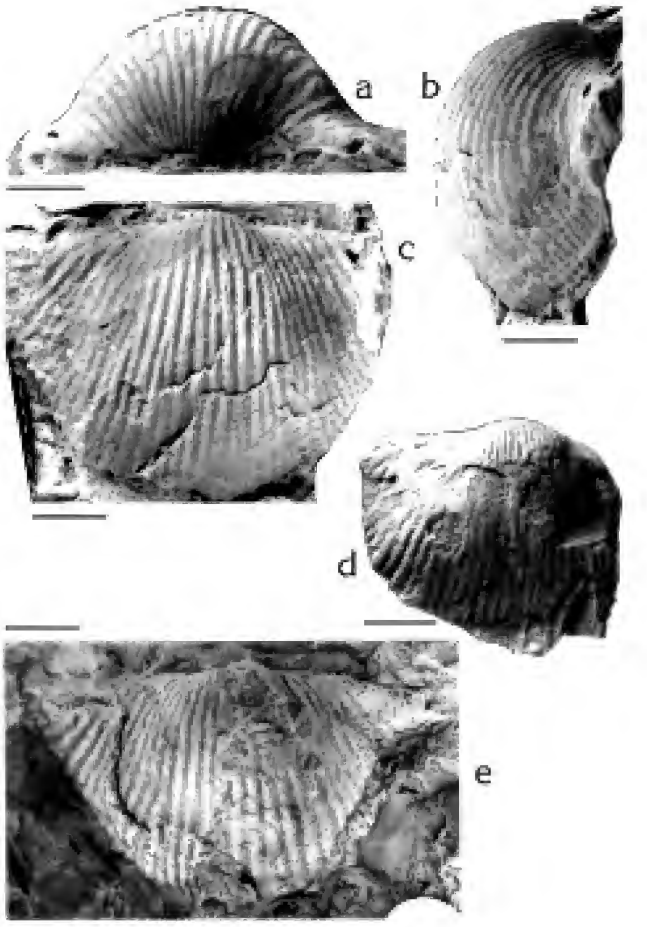

Figure 16. **a–e**: *Parachonetes buchanensis*; **a–c**, holotype NMV P47628, partially decorticated ventral valve in posterior, lateral and ventral aspects; **d**, NMV P34621, damaged ventral valve; **e**, NMV P80100, partially decorticated ventral valve with greatly extended alae. Buchan Group; Emsian. Scale bars 5 mm.

Stratigraphic distribution. Apparently Murrindal Limestone and Taravale Mudstone (see VandenBerg, p. 139, in Douglas & Ferguson, 1988), Buchan Rift, eastern Victoria.

Age. Emsian, Early Devonian.

Diagnosis. *Parachonetes* differing from *P. baragwanathi* in having more prominent alae, more rounded ribs, and less commonly occurring ventral sulcus.

Description. Shell large (Ws over 30 mm), strongly concavo-convex (Ds/Ls 0.29–0.39), with length about ⅔ width; weak ventral sulcus in one specimen. Alae broadly rounded, prominent. Ventral interarea flat, orthocline and relatively low, with open delthyrium having apical angle of about 70–80°; no other details known. Three to four hinge spines on each side; to judge by preserved bases, they were fairly robust and steeply oblique (α about 75°?). Radial

ornament coarsely costellate, ribs rather low, rounded, often rather sinuous distally, radiating from umbo and inner hinge line; 7 to 12 ribs in 5 mm at 5 mm radius, 40 to 50 ribs marginally. Ribs increase infrequently by bifurcation. Growth lines subdued, irregular.

Ventral muscle field apparently impressed at least posterolaterally; probable short, fine median septum. Valve floor, at least laterally, finely papillose. Teeth apparently well developed.

One partly decorticated fragment of the dorsal interior (NMV P79735) shows signs of what could be both median septum and cardinal process pit.

Discussion. The specimens are all either fragmentary or partly decorticated and slightly damaged ventral valves in limestone. Little is known of the dorsal valve, or of the ventral interior. When describing this species, Gill recognised that it was closely related to the *"C." robustus* group, and especially *"C." baragwanathi*. I concur, and so despite its being poorly known I am confident that *"C." buchanensis* is a species of *Parachonetes*.

Gill (1951) distinguished *"C." buchanensis* from *"C." baragwanathi* on the lack of a ventral sulcus, more rounded ribs, and different proportions. However, one of his specimens shows what could be a sulcus, a feature not always present in *baragwanathi*. Moreover, comparison of proportions is made difficult by differences in preservation: *baragwanathi* is known from rather distorted moulds in mudstone, *buchanensis* from undistorted but somewhat damaged valves in limestone. If allowance is made for this, and an estimate of width over alae in the latter is made, the two are not readily distinguished on Ls/Ws (about 0.67) or Ds/Ls (about 0.3–0.4). The appearance of the ribs has also probably been affected by greater distortion of the shells preserved in mudstone. As noted above, the two are probably synonymous.

Parachonetes? sp. cf. *buchanensis* (Gill, 1951)

"Chonetes" sp. Flood, 1974: 118–119, pl. 2, figs. 5–6.

Material. AM F77156 (formerly UNE 11071, figured pl. 2, fig. 6) and F77148 (formerly UNE 11072, figured pl. 2, fig. 5), incomplete ventral valves from the north side of Point Hibbs. The cited specimen UNE 11073 was apparently not transferred to the Australian Museum (R. Jones, pers. comm., 21 May 1998).

Stratigraphic distribution. Point Hibbs Limestone, Western Tasmania Terrane, southwestern Tasmania.

Age. *Eognathus sulcatus* Zone, early Pragian, Early Devonian.

Discussion. Flood's (1974) specimens are fairly small (the figured specimens are about 7 and 8 mm long), strongly convex, with coarse ribs (about 12 in 5 mm at 5 mm radius in F77156) radiating from the hinge; there could be small alae. In the absence of preserved hinge spines, dorsal valve or internal details, assignment to *Parachonetes* must be uncertain, but the known structures are typical of the Australian species here assigned to *Parachonetes*. Flood compared his material with *P. robustus* and *P. baragwanathi*, but the pattern of bifurcation of the ribs is most like that in some specimens of *P. buchanensis*, with which it is here formally compared.

Parachonetes koninckí Chatterton, 1973

Fig. 17

Parachonetes koninckí Chatterton, 1973: 67–69, pl. 15, figs. 1–8, 15.

Type material. HOLOTYPE ANU 18942, a silicified shell from Chatterton's locality Cyrillic-V or Cyrillic-G, "Bloomfield" property, parish of Warroo, east side of Burrinjuck Reservoir west of Yass (34°59'37"–35°S 148°49'52–55"E); figured Chatterton (1973, pl. 15, figs. 4, 8). PARATYPES ANU 18941a–e, CPC 10556–57, same locality; figured Chatterton (pl. 15, figs. 1–3, 5–7, 15).

Stratigraphic distribution. Basal *Receptaculites* Limestone Member, Taemas Formation, Canberra-Yass Shelf, south-eastern New South Wales.

Age. *Polygnathus perbonus* Zone, middle Emsian, Early Devonian.

Diagnosis. Very large coarsely ribbed *Parachonetes* with strongly oblique hinge spines; pseudodeltidium small, apical; short dental plates, short low ventral median septum, distinct ridges between ventral adductor and diductor scars; dorsal median septum prominent, anderidia with well-developed low-angle spines.

Summary description. Shell very large, ovate, strongly concavo-convex; Ls/Ws about 0.8; greatest width in front of hinge line, Wh/Ws c. 0.87. Ventral umbo broad, beak very subdued; cardinal extremities weakly convex; interarea low, flat, anacline; delthyrium wide, pseudodeltidium small, apical. Dorsal umbo flat, small elongate protegular node common; interarea very low, hypercline; notothyrium wide, filled by quadrilobate myophore flanked by chilidial plates; myophore projects into delthyrium. Hinge spines numerous (up to 6 each side?), oblique, obliquity increasing outwards to as low as 30°; outer spines curved to extend almost parallel to cardinal margin.

Ornament costellate; ribs low, rounded, 5–7 in 5 mm at 5 mm radius, radiating from umbo and adjacent hinge line. Increase mainly by bifurcation on ventral valve, intercalation on dorsal, but usually not frequently enough laterally to produce sinuous ribs. Ribs only moderately expressed internally.

Ventral interior with triangular teeth of moderate size, somewhat elongate parallel to hinge, supported by short, widely divergent dental plates. Muscle field moderately impressed posteriorly, obscure anteriorly, bounded posterolaterally by short, low, widely divergent ridges; low ridges also separate adductor and diductor scars. Median septum low, especially posteriorly, reaches c. ⅕ valve length. Valve floor anterolaterally papillose.

Dorsal interior with high, bilobed cardinal process roughly rectangular, expanded myophore angled so as to be visible from directly above valve interior; cardinal process arches over moderately deep cardinal process pit at rear of low notothyrial platform. Cardinal process lobes long, prolonged forward as distinct ridges which converge

to fuse with strong median septum. Anderidia arise from prolongations of cardinal process lobes, diverge at c. 40°, and are much shorter than median septum, which is highest anteriorly and reaches to c. ⅓ valve length. Anderidia highest at about their midlength, whence project distinct forward-pointing spines. Strong inner socket ridges diverge from posterior sides of cardinal process lobes, and rapidly die out distally; outer socket ridges low and short, overhanging deep sockets. Valve floor anterolaterally papillose.

Comparison. Chatterton's figures are excellent, so are not reproduced here. *Parachonetes koninckí* resembles *P. baragwanathi* in its short dental plates, but the former is more coarsely ribbed, and has anderidia and dorsal septum which are of similar width and height. It is closer to *P. flemingi*—the differences are discussed below.

Parachonetes flemingi Chatterton, 1973

Fig. 17

Parachonetes cf. *P. macrostriatus*.–Johnson, 1966: 369, pl. 63, figs. 9–14.
Parachonetes flemingi Chatterton, 1973: 64–67, pl. 15, figs. 9–14, 16–23.

Type material. HOLOTYPE ANU 18944, a silicified shell from Chatterton's locality Cyrillic-G, "Bloomfield" property, parish of Warroo, east side of Burrinjuck Reservoir west of Yass, NSW (34°59'37"S 148°49'55"E); figured Chatterton (1973, pl. 15, figs. 10, 14, 21). PARATYPES ANU 18943a–e, CPC 10553–55, figured Chatterton (1973, pl. 15, figs. 9, 11–13, 15–20, 22–23).

Stratigraphic distribution. Lower *Receptaculites* Limestone Member, Taemas Formation, Canberra-Yass Shelf, southeastern New South Wales.

Age. *Polygnathus perbonus* Zone, middle Emsian, Early Devonian.

Diagnosis. Large coarsely ribbed alate *Parachonetes* with strongly oblique hinge spines, small apical pseudodeltidium, prominent myophore; dental plates short; ventral median septum low; dorsal median septum long, narrow; anderidia with short low-angle spines at mid-length; valve floors strongly corrugated.

Summary description. Shell large, elongate semi-ovate, strongly concavo-convex; usually alate, maximum width at hinge line. Alae generally small, angular, somewhat flatter than remainder of shell. Ls to 30 mm, Ws to 35 mm, Ls/Ws c. 0.7–0.85, Ds/Ls to 0.5. Ventral beak low, umbo broad; interarea low, anacline; delthyrium wide, pseudodeltidium small, apical. Dorsal umbo flat; interarea very low, hypercline; notothyrium wide, almost filled by strongly protruding quadrilobed myophore, edged by narrow triangular chilidial plates. Hinge spines numerous (up to six each side?), steeply oblique orthomorph near umbo, obliquity increasing outwards (α as low as 30°); outer spines geniculate, turned outwards almost parallel with hinge line.

Ornament rather coarsely costellate; ribs rounded, somewhat irregular, medially 7–10 in 5 mm at 5 mm radius, radiating from umbo and nearby hinge line, weaker on ears. Ribs increase by both bifurcation and intercalation, most frequently laterally so that lateral ribs are distinctly sinuous. Ribs strongly corrugate valve interiors.

Ventral interior with broadly triangular, distally rounded teeth slightly divergent from hinge, supported by very short dental plates not fused to valve floor. Muscle field moderately impressed posteriorly. Median septum low, extends forward no more than ⅓ valve length, may be flattened proximally. Valve floor posterolaterally papillose.

Dorsal interior with high, arcuate, bilobed cardinal process arching over wide, shallow cardinal process pit. Anterolateral ends of cardinal process lobes form limits to low notothyrial platform, and merge with long straight anderidia which diverge forward at 30–40°. Sides of cardinal process lobes fused to low, straight inner socket ridges which broaden distally to merge with valve floor and define posterolateral limits of muscle field. Anderidia increase in height to about their midlength, where they form short blunt spines; anderidia much lower beyond spines, extend forward to no more than ¼ valve length. Notothyrial platform sometimes medially grooved; long, narrow median septum extends from it to about ⅓ valve length. Valve floor finely papillose outside anteriorly ill-defined muscle field.

Comparison. Chatterton's illustrations are good, so are not reproduced here; the summary description (using modern terminology) is provided to facilitate comparison with other species. Chatterton (1973: 65–66) and Johnson (1966) distinguished *P. flemingi* from the type species *P. macrostriatus* by its thinner shell and consequent stronger corrugation of the interior surfaces; moreover it has a shallower cardinal process pit, and less prominent papillae. Chatterton distinguished *P. flemingi* from *P. baragwanathi* by its less obviously papillose valve floors, and equally prominent dorsal median septum and anderidia, and from *P. suavis* by its greater size, shorter dorsal median septum but longer ventral median septum, straight inner socket ridges, and more strongly corrugated valve floors. As already discussed, it differs from both (and from all representatives of the *"robustus"* species-group) in its consistently anacline ventral interarea, greatly reduced alae, non-sulcate ventral valve, and lower ventral median septum

Chatterton's two species *P. koninckí* and *P. flemingi* are close, and are found at similar stratigraphic levels; the former is distinguished by larger size (Chatterton reported fragmentary specimens significantly larger than those plotted here in Fig. 17), valve floors less strongly corrugated by the external ribs, alae rudimentary or more usually absent, longer spines on the anderidia, and distinct ridges separating ventral adductor and diductor scars.

Parachonetes? bowieae (Gill, 1945)

Fig. 18

Chonetes (Chonetes) bowieae Gill, 1945: 136, pl. 8, figs. 1–2.
Chonetes bowieae.–Gill, 1951: 61–62, pl. 3, fig. 16.

Type material. HOLOTYPE NMV P123141A+B (counterparts, formerly MUGD 1908, 1909), somewhat distorted ventral internal and external moulds in mudstone from locality PL1835, Syme's Quarry, Seville East, east of Lilydale.

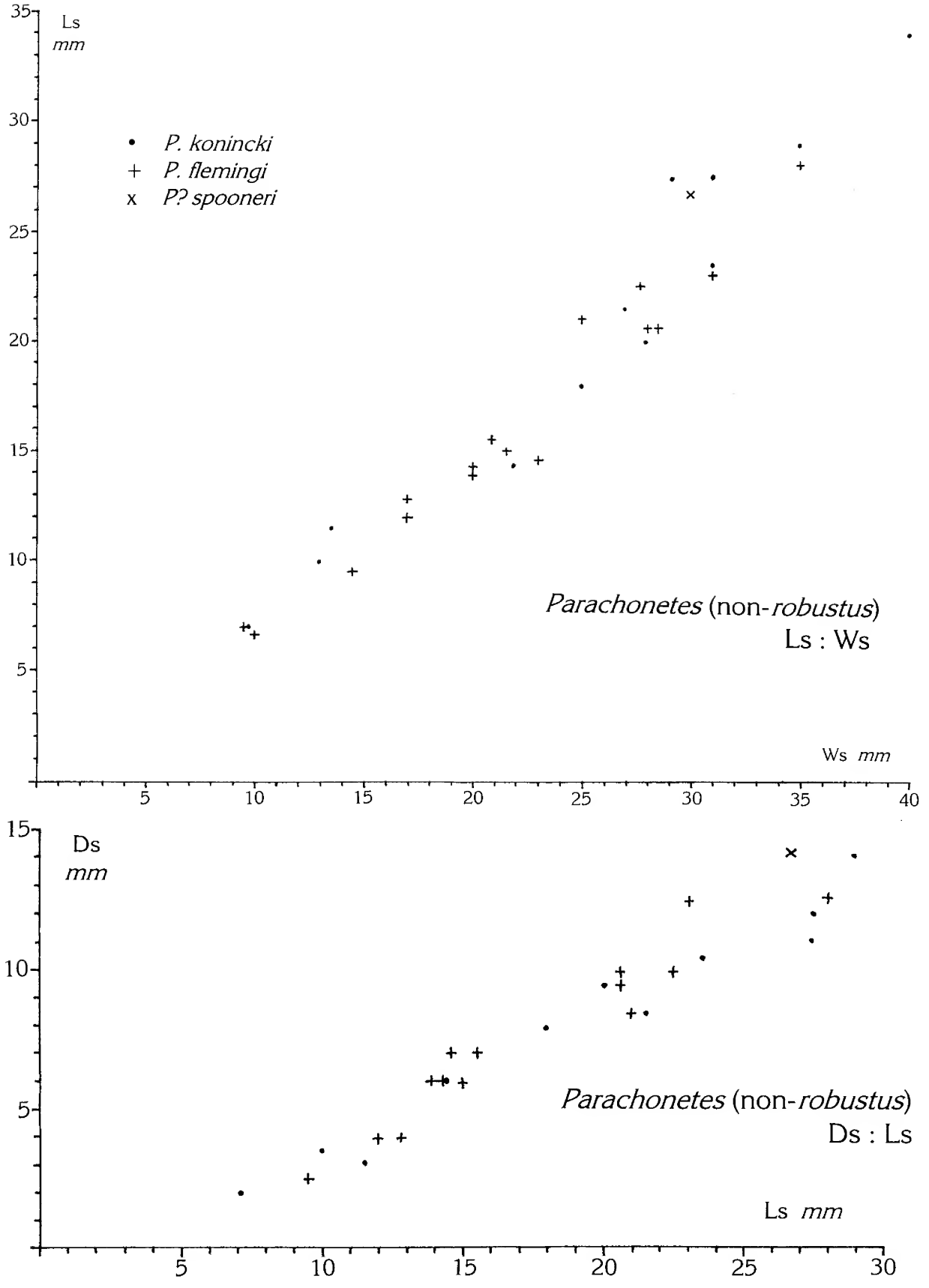

Figure 17. Scatter diagrams for length against width and depth against length for species of *Parachonetes* not assigned to the *P. robustus* group.

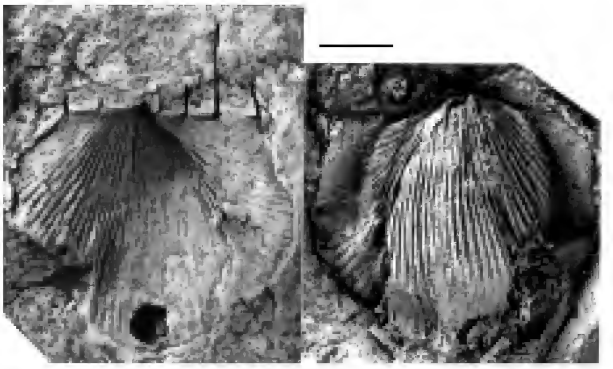

Figure 18. *Parachonetes? bowieae*; holotype, counterparts NMV P123141B (ventral external mould) and NMV P123141A (ventral internal mould); the valve has been laterally compressed. Humevale Formation; Pragian. Scale bar 5 mm.

The specimen figured by Gill (1951) and the material from localities other than the type locality referred to by him in 1945, have not been found.

Stratigraphic distribution. Humevale Formation, Melbourne Trough, central Victoria.

Age. *Boucotia loyolensis–Nadiastrophia* Assemblage Zone (Garratt & Wright, 1988); Pragian, Early Devonian.

Diagnosis. Medium-sized relatively finely costellate *Parachonetes?* in which the lateral costae radiate from very close to the umbo; hinge spines robust, upright orthomorph; alae and ventral sulcus absent.

Description. Only available specimen a laterally compressed and damaged ventral valve 17 mm long, and at least 19 mm wide; valve strongly convex, especially medially. Cardinal extremities flattened, apparently not extended as alae, so cardinal margin less than maximum width. Umbo low, beak small and barely projecting beyond cardinal margin. No sulcus. Shell costellate; ribs rounded, laterally rather sinuous, extend from umbo and possibly immediately adjacent cardinal margin. At 5 mm radius, 15 ribs in 5 mm; increase by both bifurcation and intercalation; about 60 ribs marginally. Interarea not well preserved, apparently flat and orthocline. Delthyrium open. Four hinge spines each side of umbo; spines robust, long, upright but with oblique bases, orthomorph and fairly evenly spaced.

Thin ventral median septum, fairly high posteriorly, extends forward to about ¼ valve length. Teeth apparently well developed, supported by short downwards-divergent dental plates. Muscle field obscure. Distal parts of valve floor finely and densely papillose.

Discussion. In the absence of a dorsal valve, and with costae which appear to radiate from at or very close to the beak, the generic position of this species remains uncertain. It is tentatively assigned to *Parachonetes*, and to the *"robustus"* group, described above, because of the strong similarity of the single ventral valve to those of members of that group. The ribs are a little finer, but not strikingly so (counts of ribs in 5 mm are as high as 13 in *P. robustus*, 14 in *P. baragwanathi*), and the damaged state of the valve means the existence of extended cardinal extremities cannot be ruled out. The long, distally upright hinge spines are distinctive but, other than for one specimen of *P. baragwanathi* with clearly oblique spines, only the spine bases in representatives of the *"robustus"* group are known, so this is an unreliable factor.

Parachonetes? suavis (Talent, 1963)

Figs. 14, 19

Chonetes? suavis Talent, 1963: 69, pl. 38, figs. 4–9.
Parachonetes suavis.–Johnson, 1966: 366; Chatterton, 1973: 67.

Type material. HOLOTYPE: NMV P147841 (Fig. 19a,b; formerly GSV 57123), an incomplete dorsal internal mould and counterpart ventral external mould from NMV PL576 (Talent's locality 56), near the source of Pat Creek (a tributary of the Mitchell River), Parish of Cobbannah, Tabberabbera district, East Gippsland; figured Talent (1963, pl. 38, fig. 5). PARATYPES NMV P47599 (GSV 57121; Talent, pl. 38, fig. 7), NMV P60876 (GSV 57135; Talent, pl. 38, fig. 4) and counterpart NMV P74171 (GSV 57137; Talent, pl. 38, fig. 6), NMV P147842 (GSV 57117; Talent, pl. 38, fig. 9), and GSV 57131 (Talent, pl. 38, fig. 8; this specimen was not registered on transfer, and was still missing in November 1997), all from the type locality.

Stratigraphic distribution. Lower Kilgower Member, Tabberabbera Formation, Tabberabbera Zone, eastern Victoria.

Age. Pragian, Early Devonian.

Diagnosis. Small to medium-sized, strongly concavo-convex, costellate shells with strong ribs radiating from at or near beak, crowded medially, sinuous and less crowded laterally; teeth prominent, ventral median septum short, narrow, posteriorly high; prominent arched cardinal process supported by strong, curved inner socket ridges and long, sharply geniculate anderidia, divergence proximally 50°, distally >90°; small cardinal process pit; long dorsal median septum.

Description. Shell small to medium-sized (Ls to 11 mm, Ws to 20 mm), strongly concavo-convex (Ds/Ls about 0.4). Small shells subcircular (Ls/Ws c. 0.9), with greatest width in front of hinge (Wh c. 0.9Ws), larger shells alate and so relatively wider (Ls/Ws 0.5), but alae rounded, so that width at hinge equals greatest width. Ventral interarea low, orthocline; delthyrium apparently open but apically bisected by median septum; apical angle about 100°. Dorsal interarea very narrow, hypercline; cardinal process prominent, myophore quadrilobate, flanked by large, upright, triangular chilidial plates which are conjunct apically. Hinge spines, known only by their bases, symmetrical placed. Shell thin.

Radial ornament costellate; ribs sharply rounded, high, separated by rounded furrows; ribs more crowded and prominent medially than laterally, where somewhat sinuous, least prominent on alae, and originate at or very near beak. Ribs 9–11 in 5 mm anteromedially, increase in number from about 34–38 costae to more than 50 ribs marginally by bifurcation on ventral valve, intercalation on dorsal valve.

Ventral interior with small, prominent teeth, triangular in section, slightly elongate parallel to hinge. Median septum

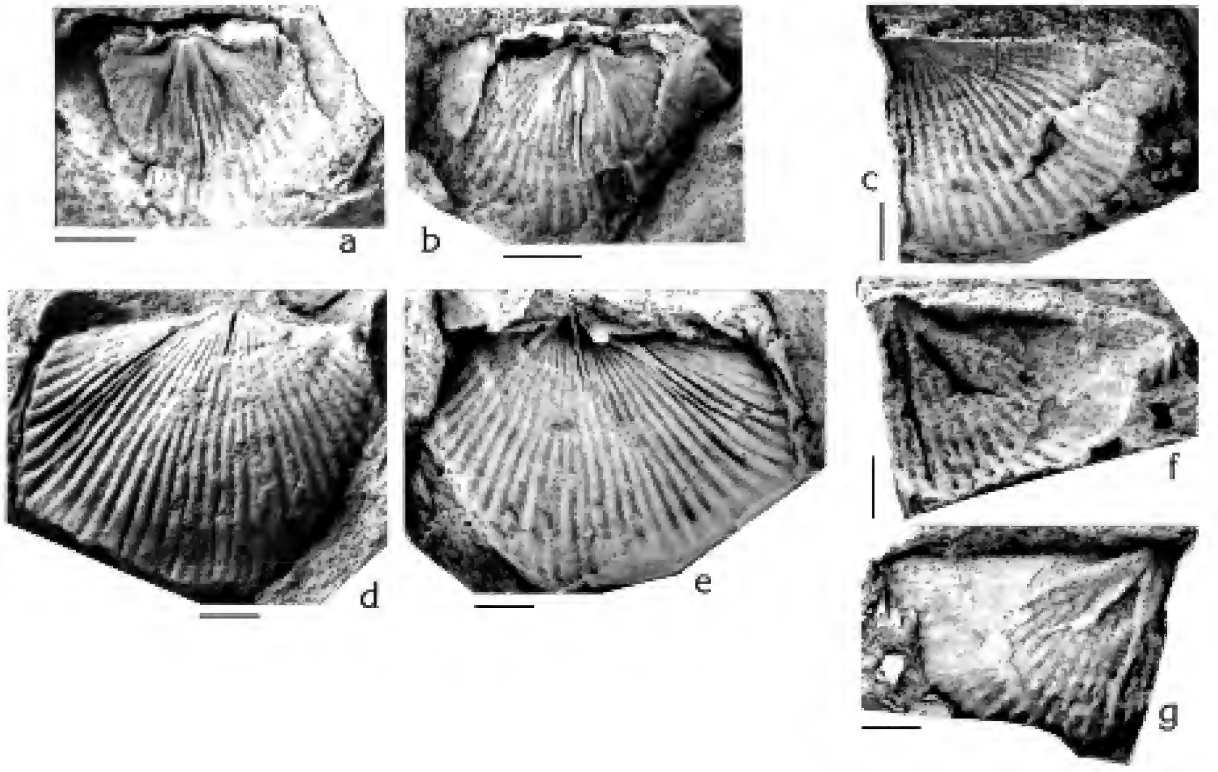

Figure 19. **a–g**: *Parachonetes? suavis*; **a,b**, holotype NMV P14781, dorsal internal mould and latex replica (shows remnants of ventral valve laterally); **c**, paratype NMV P60876, latex from incomplete dorsal external mould; **d,e**, paratype NMV P47599, distorted ventral internal mould and latex replica; **f,g**, paratype NMV P74171, counterpart to P60876, incomplete dorsal internal mould and latex replica. Lower Kilgower Member, Tabberabbera Formation; Pragian. Scale bars 2 mm.

narrow, high (especially posteriorly, where it reaches level of interarea), but short (no longer than ¼ valve length). Muscle field gently impressed posteriorly, very faint anteriorly, probably flabellate, extends forward to about ⅓ valve length. The one reasonable interior lacks large endospines, but there is a suggestion of numerous fine papillae; valve floor strongly corrugated by external ornament.

Dorsal interior with prominent, curved inner socket ridges, distally parallel with hinge line, proximally fused to prominent, arched, bilobed cardinal process. Outer socket ridges low, short. Cardinal process pit small but distinct. Prominent anderidia arise at base of cardinal process and diverge at about 50°; proximally low and wide, they rise steadily to about ⅓ valve length, where each bears a very short spine (c. 0.5 mm). Beyond that point, anderidia low, narrow, diverging at >90° to reach about 60% Ld. Median septum prominent, long (reaches two thirds valve length); posterior half broad, rising forward, and in one of two specimens bears shallow median furrow; anterior half narrow, can develop one or two short lateral spurs. Papillae variable, radially arrayed below inter-rib furrows, may be large anteromedially. Musculature obscure.

Discussion. Johnson (1966) unequivocally placed *Chonetes? suavis* in *Parachonetes*, but the type of hinge spine is unknown, and the ornament (more or less radial from the umbo) is atypical for the genus. Johnson also suggested that it could be synonymous with *P. baragwanathi*, but there are significant differences, not least in details of the cardinalia (*suavis* has longer, more divergent anderidia, whose proximal and distal ends meet at a distinct angle; longer and posteriorly expanded dorsal median septum; curved inner socket ridges) and ornament (the ribbing in *suavis* is finer, and increases exclusively by intercalation on the dorsal valve). The two species are known from different localities in the same formation.

Parachonetes? spooneri (Talent, 1956)

Figs. 17, 20

Chonetes spooneri Talent, 1956: 44–45, pl. 3, fig. 9.
Parachonetes spooneri.–Chatterton, 1973: 66.

Type material. HOLOTYPE NMV P122903 (Fig. 20a,b; formerly MUGD 2186), a dorsal valve from Spooner Creek about 400 m below the western contact between limestone and the Snowy River Volcanics due south of McRae's homestead, The Basin, Buchan, East Gippsland; figured Talent (1956, pl. 3, fig. 9). PARATYPE NMV P122904 (MUGD 2219), a worn and auloporoid-overgrown ventral valve; same locality.

Stratigraphic distribution. Buchan Caves Limestone (in muddy limestone about the middle of the formation), Buchan Rift, eastern Victoria.

Age. *Polygnathus dehiscens* Zone (Mawson *et al.*, 1992), Early Emsian, Early Devonian.

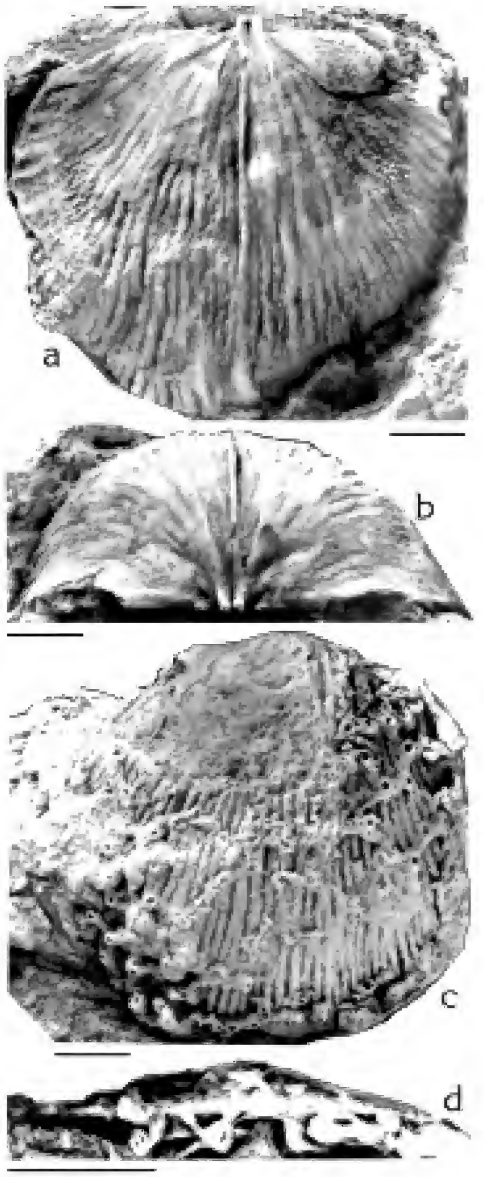

Figure 20. **a–d**: *Parachonetes? spooneri*; **a,b**, holotype NMV P122903, dorsal interior in dorsal and posterior aspects; **c,d**, paratype NMV P122904, auloporoid-encrusted ventral valve in ventral and posterior aspects, the latter showing prominent teeth and narrow arcuate pseudodeltidium (both partly obscured by corallites). Buchan Caves Limestone; Emsian. Scale bars 5 mm.

Diagnosis. Large, strongly concavo-convex coarsely costellate shell, ribs radiating from hinge line close to umbo; teeth robust; cardinal process elevated, posteriorly directed, deeply bifid; cardinal process pit shallow, elongate; sockets short, deep, divergent, inner socket ridges straight, extended as low broad ridges laterally; anderidia short, geniculate, proximally diverge at 30°; dorsal median septum long, widened posteriorly around cardinal process pit.

Description. Shell large (Ls to 27 mm, Ws to 30 mm), strongly concavo-convex (Ds/Ls c. 0.5), slightly wider than long (Ls/Ws c. 0.9), with cardinal angles obtuse and greatest width at about midlength. Ventral beak low, interarea anacline, concave; delthyrium wide, parabolic, with narrow, arcuate, apical pseudodeltidium. Dorsal interarea very low, attitude uncertain. Cardinal process relatively small; posteriorly directed myophore of two triangular lobes separated by a deep furrow; posterior face of each lobe weakly bifid, with adaxial ridge higher than abaxial ridge; narrow chilidial plates flank myophore. Hinge spines and spine bases unknown.

Radial ornament coarsely costellate; ribs rounded and fairly regular, separated by narrow furrows, radiate from beak and immediately adjacent cardinal margin. Increase by bifurcation on ventral valve, apparently by intercalation on dorsal valve. Rib spacing medially about eight in 5 mm at 5 mm radius, coarsening outwards; number of ribs at shell margin not known.

Teeth small but prominent, triangular in section, slightly elongate parallel to hinge; remainder of ventral internal structures unknown.

Dorsal interior irregularly radially corrugated by impression of ribs. Cardinal process prominent, posteriorly directed, deeply bilobed. Outer socket ridges triangular, short but relatively prominent, overhang small, deep, divergent dental sockets; inner socket ridges short, straight, proximally narrow and fused with cardinal process, distally expanded into very subdued ridges. Median septum low but wide proximally, supporting cardinal process and medially depressed by small, elongate cardinal process pit; septum rises gently to about its midlength, extends to about ⅔ valve length. Anderidia short, narrow, arise at junction of median septum with inner socket ridges and cardinal process lobes, diverge at about 30°, and reach about 1/5 valve length; distal ends turn inwards almost parallel with median septum. Adductor muscle field smoother than remainder of valve floor, anterolaterally bounded by low, wide ridge. Outside muscle field, valve floor densely covered by small radially elongate papillae.

Discussion. This species is represented by only two specimens, one of which is encrusted by an auloporoid coral, and the ventral interior remains essentially unknown. Chatterton thought *P.? spooneri* close to his new species *P. flemingi*, but the cardinal process pit is much smaller, and the cardinal process does not strongly over-arch it in the manner so typical of *Parachonetes*. The anderidia are relatively shorter than in *P. flemingi*, and the dorsal septum is not nearly as wide posteriorly. It also differs from typical *Parachonetes* in that the ribs radiate from a relatively short median section of the hinge line; in that, it resembles *P.? bowieae* and *P.? suavis*, species only tentatively assigned to the genus but in many other ways similar to the *P. robustus* species-group.

There is some similarity to the notiochonetine *Allanetes neozelanica* Boucot & Johnson, 1967 (Emsian, New Zealand), a strongly concavo-convex coarsely ribbed form with a similarly elevated cardinal process, small but distinct cardinal process pit, long median septum and weakly divergent anderidia. However, unlike in *P.? spooneri* its cardinal process is flanked by strong cardinal crests (interpreted as widely disjunct chilidial plates by Boucot & Johnson, and by Racheboeuf, 1998: 76; Boucot & Johnson's

pl. 22, figs. 6–7, shows that they are not attached to the edge of the notothyrium), and the dorsal valve floor is not strongly corrugated by the exterior ornament as in *P.? spooneri*. Moreover, *A. neozelanica* has (unusually) a ventral fold and dorsal sulcus.

Parachonetes? sp.

?*Devonochonetes* sp. 1 Lenz & Johnson, 1985: 58–59, pl. 16, figs. 1–4, 6–8.

Material. AM F64783–87, from between 520 and 825 m above the base of the Garra Formation in the composite section of Lenz & Johnson (1985: 38–39) Wellington Caves, near Wellington.

Stratigraphic distribution. Garra Formation, Molong High, central New South Wales.

Age. Probably *Eognathus sulcatus* Zone (see Lenz & Johnson, text-fig. 4), early Pragian, Early Devonian.

Summary description (modified after Lenz & Johnson, 1985). Shell small (Ls to 8 mm, Ws to 10 mm), strongly concavo-convex, subovate to transverse, with small alae. Ornament finely costellate (15–17 in 5 mm at 5 mm radius); ribs rounded, increasing in width forward, occasionally bifurcating, radiating from hinge line near umbo. Ventral umbo rounded; interarea low, concave, apsacline; delthyrium small, open. Dorsal interarea very low, hypercline; myophore trilobed. Hinge spines bases steeply oblique, few, robust, asymmetrically placed. Shell thin, valve interiors strongly corrugated.

Ventral interior with small triangular teeth, short low median septum. Ventral muscle field obscure, not impressed.

Dorsal interior with strong, straight, widely divergent inner socket ridges; cardinal process wide, directed posteriorly, distally bilobed, the lobes not deeply separated, and posteriorly weakly furrowed. No obvious cardinal process pit. Anderidia low, narrow, arise just in front of cardinal process, diverge forward at c. 40°, extend to about 1/5 valve length. Low breviseptum arises at c. ⅓ valve length.

Discussion. In several important aspects the above description differs from the original (despite the original illustrations being quite good), especially regarding the dorsal interior. The authors were clearly very uncertain about the position of this form, and were probably persuaded to refer it tentatively to *Devonochonetes* because they perceived the cardinal process to have a trilobed myophore. However, AM F64785 and F64786 (pl. 16, figs. 3, 4) clearly show what has usually been called a quadrilobed myophore (see Racheboeuf, 1998: 14). Moreover, *Devonochonetes* characteristically has distinctly oblique hinge spines, a strongly impressed ventral muscle field, a large pseudodeltidium, and a long dorsal median septum. Racheboeuf (1998: 41) assigned this form to *Johnsonetes*, but that genus lacks the first spine on the left side, which does not appear to be the case with the present species, and it also has a well-developed dorsal median septum. The shell shape and ornament, and the asymmetrically placed probably steeply oblique orthomorph spines all recall *Parachonetes*, but that genus also has a distinctive cardinal process arched above a deep cardinal process pit. The generic position of this species therefore remains very uncertain, but on balance is closest to *Parachonetes*, to which I tentatively refer it.

This species differs from all other Australian species assigned to *Parachonetes* in smaller size, finer ribs, and lack of a distinct cardinal process pit. Lenz & Johnson (1985) drew comparisons with *Devonochonetes zeravshanicus* Gratsianova (in Gratsianova & Rzhonsnitskaya, 1977), but that species is much larger, with numerous sharply oblique hinge spines and a better developed ventral median septum.

Anopliidae Muir-Wood, 1962

Holynetinae Racheboeuf, 1981

Septachonetes Chatterton, 1973

Type species. *Septachonetes melanus* Chatterton, 1973, pp. 77–78; pl. 14, figs. 18–25; pl. 17, figs. 1–2. Emsian, New South Wales.

Diagnosis (modified from Racheboeuf, 1998: 62). Very small elongate semi-oval shell with fine costellate ornament, two upright spines on right side only; dorsal interior with deep cardinal process pit, no median septum, weak widely divergent anderidia and three to five pairs of irregular sinuous accessory septa developed anteromedially.

Remarks. *Holynetes* Havlíček & Racheboeuf, 1979, from the Eifelian of Bohemia, is externally very similar, but rather larger and more strongly concavo-convex; moreover the capillae increase in number rather than size distally. Internally it differs in having shorter and less well-developed anderidia, and a single pair of long accessory septa which do not extend beyond midlength, instead of the several anteriorly placed pairs in *Septachonetes*.

Septachonetes melanus Chatterton, 1973

Septachonetes melanus Chatterton, 1973: 77–78; pl. 14, figs. 18–25; pl. 17, figs. 1–2.

Type material. HOLOTYPE ANU 18940, a silicified ventral valve from Chatterton's locality A, on the east side of a creek flowing south into Burrinjuck Reservoir about 3 km south of Good Hope, west of Yass, NSW (34°57'14"S 148°48'55"E); figured Chatterton (1973, pl. 14, fig. 20). PARATYPES ANU 18939a–d, CPC 10566–68.

Stratigraphic distribution. Warroo Limestone Member, upper Taemas Formation, Canberra-Yass Shelf, southeastern New South Wales.

Age. Emsian, Early Devonian.

Diagnosis. Moderately concavo-convex *Septachonetes* with anderidia diverging at 70°, and 3–4 pairs well-developed anteriorly placed accessory septa.

Remarks. The species has been well described and illustrated by Chatterton. In summary, the shell is up to 4 mm long, 5.5 mm wide, Ls/Ws about 0.75, Ds/Ls c. 0.3. The two hinge spines are apparently slightly intraverse and may be weakly cyrtomorph. Ornament is very fine—Chatterton records about 45 ribs at the margin of a shell 5

mm wide—with the ribs increasing in size with shell growth, but only rarely in number. The ventral interior is simple, with a short, low median septum and small teeth. The short, narrow anderidia diverge at about 70–80°. In front of them is a median zone with coarse papillae, flanked by several pairs of pustulose accessory septa.

Because of the pattern of hinge spines, Chatterton thought this species may have arisen by neoteny from *Protochonetes latus*, but the internal features of both valves are very different. The two species co-exist in the Warroo Member.

Septachonetes micrus (Gill, 1951)

Fig. 21

Chonetes micrus Gill, 1951: 62–63, pl. III, figs. 6–11.

Type material. HOLOTYPE NMV P14698 and counterpart P14699 (Fig. 21a,b), ventral internal and external moulds, from locality PL1813, Hull Road, Mooroolbark, north of Melbourne (a cutting on the east side of Hull Road just north of its intersection with Taylor Road); Kilsyth 1:25,000 sheet, grid reference 521166; figured Gill (1951, pl. III, figs. 9–11). PARATYPE NMV P14700 and counterpart P14701, dorsal internal and external moulds, same locality; figured Gill (1951, pl. III, figs. 6–8).

Other material. Topotypes NMV P14705–6, cited Gill (1951: 63); NMV P14702, cited Gill (1951: 62), probably from PL1802 (Gill's locality 2: "Wilson's" on Albert Hill Road near Lilydale, north of Melbourne).

Stratigraphic distribution. Humevale Formation, Melbourne Trough, central Victoria.

Age. Pragian, Early Devonian.

Diagnosis. Strongly concavo-convex species of *Septachonetes* with nearly smooth cardinal extremities, short dental plates, prominent anderidia diverging at about 55°, low irregularly developed accessory septa.

Description. Shell small (Ls to 5 mm, Ws to 6.5 mm), suboval (Ls/Ws c. 0.8), strongly concavo-convex (Ds/Ls about 0.4). Cardinal angles either moderately obtuse, when Wh/Ws greater than 0.9 and greatest width towards midlength, or bluntly alate. Ventral umbo low, beak small but sharp, interarea and delthyrial structures unknown. Dorsal umbo flat, with small elongate protegular node; interarea almost linear, anacline; notothyrium filled by protruding quadrilobed myophore and narrow triangular chilidial plates. Two thin, more or less upright, weakly intraverse cyrtomorph spines on right side of beak.

Ornament finely costellate; capillae rounded, radiating from beaks, separated by deep narrow furrows, and increasing in number by bifurcation on ventral valve, intercalation on dorsal valve. Over 40 capillae at margin of large shells (16–17 in 5 mm).

Ventral interior with small triangular teeth apparently supported by short divergent dental plates. Muscle field obscure; median septum posteriorly high and thin, prolonged forward as a fine ridge to about a quarter of valve length. Traces of external furrows posterolaterally subdued and bear coarse, slightly radially elongate and rather sparse papillae. Rest of valve floor fairly strongly reflects external ornament, and traces of furrows bear numerous much finer papillae.

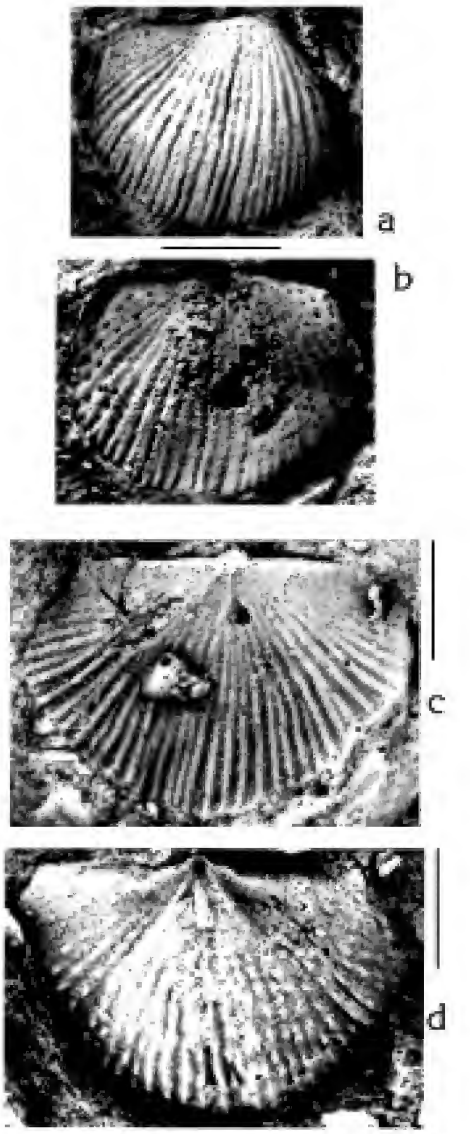

Figure 21. **a–d**: *Septachonetes micrus*; **a,b**, holotype NMV P14699, latex from ventral external mould, and counterpart P14698, ventral internal mould; **c,d**, paratype NMV P14701, latex from dorsal external mould, and counterpart NMV P14700, latex from dorsal internal mould. Humevale Formation; Pragian. Scale bar 2 mm.

Dorsal interior with small, raised, proximally bilobed cardinal process arched over shallow but well-developed cardinal process pit. Inner socket ridges prominent, straight, diverging at about 150° from sides of cardinal process lobes; initially thin and high, becoming low and broad distally. Prominent anderidia diverge at about 55°, and extend from forward ends of cardinal process lobes to about a fifth of valve length. Structure between anderidia on paratype, thought by Gill (and Chatterton, 1973: 77) to be low, flat-topped median septum, is not aligned with valve mid-line,

and is probably a preservational artefact. External ornament moderately reflected on valve floor (which is thus smooth just in front of hinge line), with traces of intercapillar furrows bearing prominent elongate papillae which coalesce anteriorly and anterolaterally to form low irregular accessory septa.

Comparison. As considered likely by Chatterton (1973: 77), *S. micrus* is very close to *S. melanus*. Of similar outline and ornament, externally they differ only in the former being slightly larger and more strongly convex, so that smaller shells would be difficult to distinguish. The faint ventral sulcus reported by Gill for *S. micrus* is not continuous to the anterior margin, but confined to the centre of the valve, so is probably not a true sulcus but either teratogenic or a preservational artefact. The internal structures of the two species are also very similar, although the reflection of the external ornament is stronger in *S. micrus*. Moreover its teeth appear to be less transverse and are supported by narrow dental plates, and the coarse papillae on the lateral floor of the ventral valve are less numerous. In the dorsal interior the anderidia are less divergent, the accessory septa not as strongly developed.

Chonetoidea *incertae sedis*

"Chonetes" taggertyensis Gill, 1945

Figs. 22, 23

Chonetes (Chonetes) taggertyensis Gill, 1945: 137–138, pl. VIII, figs. 6, 8, 13.
? *Chonetes?* sp. A Talent, 1963: 69, pl. 41, figs. 5–6.

Type material. HOLOTYPE NMV P27979A+B (Fig. 22a–e; formerly MUGD 1910, 1911), an incomplete ventral internal mould and counterpart external mould, from Blue Hills, Taggerty, about 85 km northeast of Melbourne (37°19'S 145°43'E); figured Gill (1945, pl. VIII, figs. 8, 13). PARATYPE NMV P27980 (formerly MUGD 1912), an incomplete ventral internal mould figured Gill (1945, pl. VIII, fig. 6); same locality.

Other material. Possibly NMV P60907 (Fig. 23; formerly GSV 57316), a ventral internal mould from locality NMV PL576 (Talent's locality 56), near the source of Pat Creek (a tributary of the Mitchell river), Parish of Cobbannah, Tabberabbera district, East Gippsland, figured Talent (1963, pl. 41, figs. 5, 6).

Stratigraphic distribution. The type locality is in an uncertain Lower Devonian horizon in the eastern Melbourne Trough, central Victoria; Talent's specimen is from the lower Kilgower Member, Tabberabbera Formation, Tabberabbera Zone, eastern Victoria.

Age. Pragian, Early Devonian.

Diagnosis. Medium-sized relatively convex capillate chonetoid with flat orthocline ventral interarea, prominent arcuate pseudodeltidium; hinge spines few, probably oblique; teeth prominent, triangular; ventral muscle field large, posteriorly deeply impressed, smooth; prominent ventral median septum high, thickened against valve floor, prolonged anteriorly as long, low myophragm; ventral valve floor peripherally heavily papillate outside zone of weak radial ridges; large papillae posterolateral to muscle field. Dorsal valve unknown.

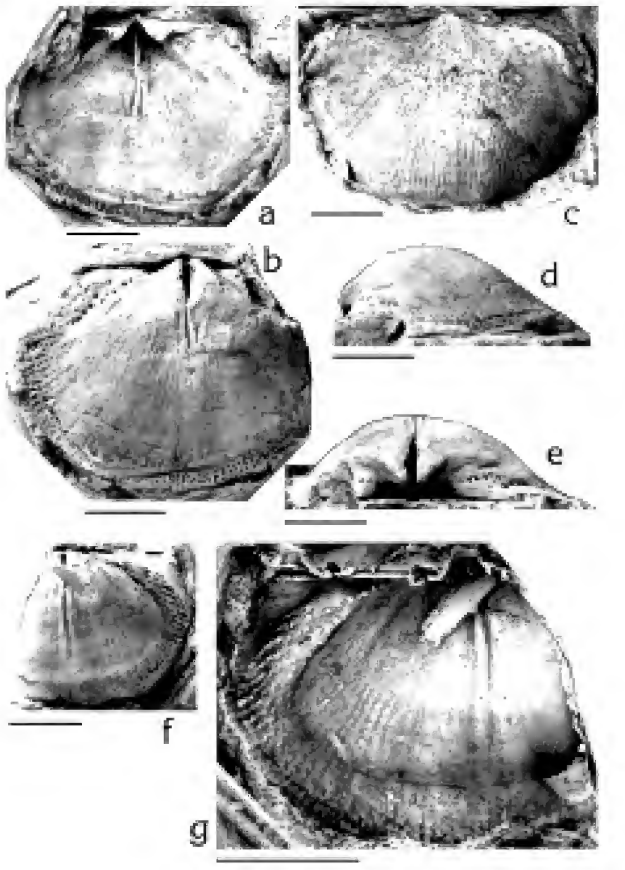

Figure 22. a–g: *"Chonetes" taggertyensis*; **a–e**, holotype NMV P27979A–B (counterpart ventral internal and external moulds): internal mould in ventral, lateral and posterior aspects (b, d,e) and latex replica (a), latex from external mould (c); **f,g**, paratype NMV P27980, incomplete ventral internal mould and latex replica (in slightly anteroventral aspect, showing raised arcuate pseudodeltidium). Pragian? Scale bars 5 mm.

Description. Shell medium-sized (Ls to 15 mm, calculated Ws 18.4 and 20.9 mm), ovate, Ls/Ws about ⅔. Greatest width apparently at about midlength (Wh/Ws about 0.8), cardinal angles obtuse. Rather strongly convex, Ds/Ls about 0.4; convexity greatest at midlength, much reduced towards margin and cardinal extremities. Ventral beak small, low, rounded; interarea orthocline, flat, triangular; delthyrium triangular, partly closed by prominent arcuate pseudodeltidium. Hinge spines not preserved, but bases (four each side) oblique.

Ornament finely costellate, of low rounded capillae radiating from umbo and increasing in size distally; about 16 in 5 mm at 5 mm radius, and 15/cm at anterior margin. Increase in number by intercalation, rare before midlength. Ribs fainter towards cardinal extremities.

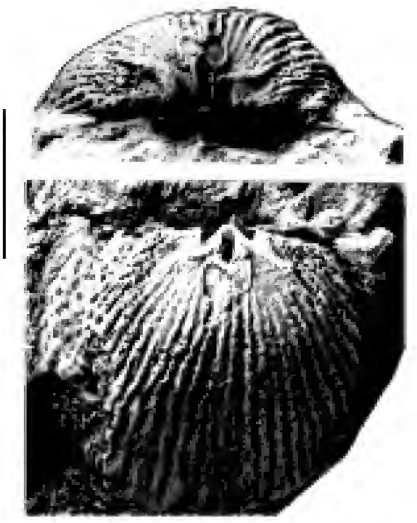

Figure 23. ?*"Chonetes" taggertyensis*; NMV P60907, ventral internal mould in posterior and ventral aspects. Tabberabbera Formation; Pragian. Scale bar 5 mm.

Ventral interior with prominent, wide, subtriangular teeth buttressed against valve floor on either side of muscle field. Inner margins of teeth (and delthyrium) diverge at about 80°. Muscle field large, widely flabellate, posteriorly deeply impressed, anteriorly poorly differentiated; floor smooth; length about 0.4Ls. Narrow, raised, ovate adductor scars faintly visible to either side of well-developed median septum. Median septum high, basally thickened, tapering upwards, extends to about ¼ valve length, prolonged as well-developed myophragm bordered by narrow furrows (vascula media?) to valve midlength or beyond. Valve floor beyond muscle field faintly radially furrowed. Visceral cavity bounded distally by zone of radially arranged papillae concentrated below inter-rib furrows. On paratype, marginal zone strongly marked off from visceral cavity and valve floor near cardinal angles by concentric furrows. Papillae significantly coarser posterolateral to muscle field.

Dorsal valve unknown.

Discussion. Only two incomplete ventral valves are known. In the absence of dorsal valves and details of the hinge spines, the generic and even familial position of *"Chonetes" taggertyensis* remains highly uncertain. Boucot & Harper (1968: 151) thought it could be either *Chonetes* or *Protochonetes*, but the latter is unlikely in view of the long ventral median septum and prominent pseudodeltidium. With fine ribs radiating from the beak, it is clearly not a parachonetine. It cannot be excluded from the Strophochonetinae, but would be unusual for that subfamily in its lack of an accentuated median rib, its relatively strong convexity, and its prominent teeth and ventral median septum.

The distinct papillose marginal zone, otherwise nearly smooth valve floor (including the cardinal extremities), and concentration of particularly large papillae posterolateral to the muscle field in *"C." taggertyensis* can be seen in a number of described Devonian species belonging to several chonetid subfamilies, such as *Plebejochonetes* sp. 2 of Racheboeuf (1976, especially pl. 2, fig. 2—but the median septum is shorter); the type species *Plebejochonetes semiradiatus* (Sowerby, 1842), especially the syntype valves figured by Racheboeuf & Fuchs (1988: pl. 1, fig. 3b; pl. 2, fig. 2b); topotypes of the type species *Chonetes sarcinulatus* (Schlotheim, 1820) figured by Racheboeuf (1978, figs. 3[6] and 4[1–3]); *Devonochonetes? kerfornei* (Renaud, 1942) of Racheboeuf (1981, especially pl. 23, figs. 11, 20–22 and pl. 24, fig. 1); and ventral valves of *Notiochonetes falklandica* (Morris & Sharpe, 1846) figured by Isaacson (1977, pl. 5, figs. 4–6). This diversity (both taxonomic and palaeogeographic) simply makes it clear that the position of Gill's species (which does not appear to be close to any other Australian Silurian-Devonian species) cannot be clarified in the absence of data on hinge spines and the dorsal valve.

The single ventral internal mould NMV P60907 (Fig. 23) from the Kilgower Member, described as *Chonetes?* sp. A by Talent, 1963, is strongly convex, subovate (Ls = 9.8 mm, Ws = 12.8 mm, Ls/Ws 0.77), with robust oblique spine bases, and triangular teeth supported by dental plates which continue forward as weak ridges posterolaterally bounding the gently impressed flabellate muscle field. The valve floor is flattened near lateral margins. A short, high, thick median septum starts in front of the beak and is bordered by narrow grooves. These grooves also define the margins of the distinct raised ovate diductor scars which are immediately in front of the median septum. The valve floor is densely papillose, the papillae aligned below the inter-rib furrows and very coarse posterolaterally. The overall shape, the shape of the median septum, the distribution of papillae on the valve floor, and the distinct diductor scars all recall *"C." taggertyensis*. The obvious differences are the strong internal reflection of the external ribs, implying that the ribs themselves are much stronger, and the distinct dental plates. Talent's form is closer to *"C." taggertyensis* than to any other Australian species, and they are here tentatively placed in synonymy, but without more material this is far from established.

"Chonetes" ruddockensis Gill, 1945

Fig. 24a,b

Chonetes (Chonetes) ruddockensis Gill, 1945: 139–140, pl. 8, fig. 10.

non *Chonetes* aff. *ruddockensis*.–Gill, 1950: 249, pl. I, fig. 36.

Type material. HOLOTYPE NMV P122947 (Fig. 24a; formerly MUGD 1914), a ventral internal mould in siltstone from locality PL1820, "Ruddock's Quarry", on hillside c. 200 m west of Edward Road and 400 m north of intersection with Switchback Road, Chirnside Park; Kilsyth 1:25,000 sheet 7922-2-IV, grid reference 516215; figured Gill (1945, pl. VIII, fig. 10); Humevale Formation.

Other material. NMV P122948 (formerly MUGD 1916), a poorly preserved ventral external mould in silty sandstone from near Strath Creek, Kinglake.

Stratigraphic distribution. Humevale and Killingworth Formations, Melbourne Trough, central Victoria.

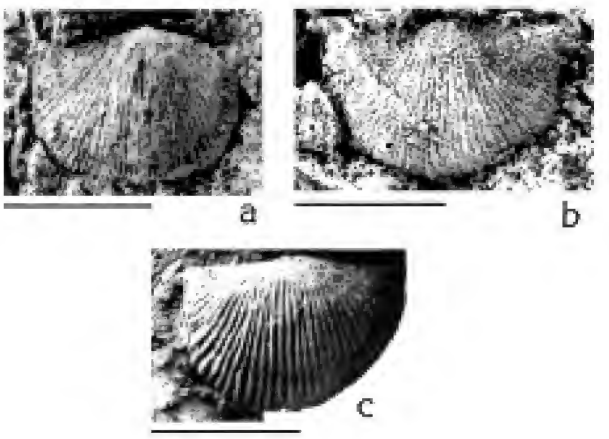

Figure 24. **a,b**: *"Chonetes" ruddockensis*; **a**, holotype NMV P122947, ventral internal mould; **b**, NMV P122948, latex from ventral external mould. Humevale and Killingworth Formations; Lochkovian. **c**: *Chonetes* aff. *ruddockensis* of Gill (1950); NMV P14804, ventral internal mould. Bell Shale, Tasmania; Lochkovian. Scale bars 5 mm.

Age. Lochkovian, Early Devonian.

Description (holotype). Shell small (Ls 5.5 mm, Ws 7.2 mm), subquadrate (Ls/Ws 0.76), greatest width at about midlength (Wh/Ws 0.97), cardinal angles extended as small ears. Profile fairly strongly convex (Ds/Ls 0.33). Interarea unknown. At least four pairs of long, thin, slightly sinuous, more or less upright hinge spines. External ornament of low, rounded, even capillae (about 23 in 5 mm at 5 mm radius), increasing by bifurcation, separated by narrow furrows; about 54 capillae at margin.

Ventral internal details not well preserved, obscured by limonite. Teeth small. Median septum very subdued, fine, extending to about midlength, apparently widened posteriorly. Valve floor probably papillose marginally, but density and pattern unknown.

Dorsal valve unknown.

Discussion. NMV P122948 is a poorly preserved and doubtfully complete ventral external mould 8.8 mm wide that adds little to the above description. The maximum width is at the hinge line, and the ears appear to be slightly more prominent and more rounded than in the holotype. Gill referred to specimens from a number of other localities, but these have not been recognised in the university and museum collections.

With such inadequate material, and no dorsal valves, the generic and even family position of this species is also highly uncertain. Boucot & Harper (1968: 151) thought it could be either *Chonetes* or *Protochonetes*. *Protochonetes* has a short ventral median septum while that in *C. (Chonetes)* is long, but both have oblique hinge spines (more variable in *Protochonetes*). *Protochonetes* has a posteriorly enlarged ventral median septum, as does *Strophochonetes*, which tends to be larger and usually has an enlarged median rib.

Gill (1950) thought that NMV P14804 (Fig. 24c) from the Bell Shale in Zeehan, Tasmania, was comparable with *"C." ruddockensis*. It is a poorly preserved ventral internal mould 7.9 mm wide, non-alate (Wh/Ws 0.96), strongly convex (Ds/Ls 0.58) with strong radial capillae (17 in 5 mm at a radius of 5 mm) increasing by both intercalation and bifurcation; there are fairly strong papillae towards the cardinal angles and possibly submarginally. Information on hinge spines and internal details is wanting, so generic assignment is impossible, but on shape and ornament alone I do not consider it at all close to *C. (C.)? ruddockensis*.

"Chonetes" foedus Talent, 1963

Fig. 25

Chonetes? foedus Talent, 1963: 68–69, pl. 37, figs. 8–16, pl. 38, figs. 1–3; Johnson, 1966: 366.
Allanetes? foedus.–Boucot & Johnson, 1967: 142.

Type material. HOLOTYPE NMV P60871 (Fig. 25b; formerly GSV 57100), a ventral internal mould from Talent's locality 48, Tabberabbera area; this is on a tributary gully of the left branch of Dead Bull Creek 2.65 km south-southeast of its junction with the Wentworth River, Parish of Nungatta; figured Talent (1963, pl. 37B, figs. 9, 15). PARATYPES NMV P47601 (GSV 57112), a distorted dorsal external mould figured Talent (pl. 37B, fig. 8); NMV P74170 (GSV 57102), an incomplete ventral internal mould figured Talent (pl. 38, fig. 2).

Other material. Figured topotypes NMV P47600 (GSV 57111), 60872–74 (GSV 57095, 57104, 57106), 74168–69 (GSV 57109, cited as 57103, and 57007).

Stratigraphic distribution. Basal Dead Bull Member, Tabberabbera Formation, Tabberabbera Zone, eastern Victoria.

Age. Pragian, Early Devonian.

Description. Shell medium-sized (Ls to 12 mm, Ws to 21 mm), semiovate (Ls/Ws c. 0.6), greatest width towards midlength (Wh/Ws c. 0.9). Ventral valve strongly convex, with flattened (but not laterally extended) cardinal extremities, sometimes with weak sulcus. Dorsal valve slightly concave; body cavity relatively deep. Ventral interarea obscure, possibly low orthocline; delthyrial structures unknown. Dorsal interarea narrow, catacline to hypercline; small quadrilobate myophore flanked by triangular disjunct chilidial plates. Hinge spines apparently upright or slightly inwards-oblique, probably straight.

Radial ornament costellate, most pronounced medially on both valves, becoming very faint towards cardinal angles. About 22–24 high costae (anteromedian spacing 15–17/cm) irregularly radial medially, sharply rounded with narrow interspaces. Ribs increase by bifurcation on ventral valve, intercalation on dorsal valve, such that there are about twice as many ribs marginally as on umbo. Laterally, rapid increase in ribs beyond about 4 mm radius causes distinct change in rib direction. Change in rib direction gradual on ventral valve, such that ribs are markedly curved, but quite abrupt on dorsal valve, such that ribs are straight or only weakly curved distally. Distinct dorsal protegular node.

Teeth small. Median septum narrow, high and somewhat swollen posteriorly in some specimens, does not extend beyond ¼ valve length. Muscle field obscure. A few large papillae on inner surfaces of ears.

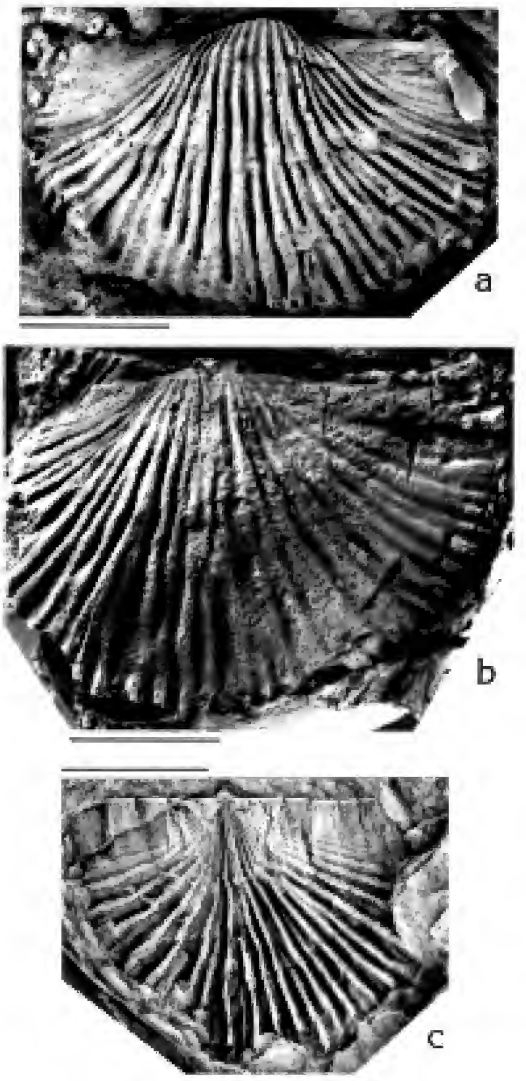

Figure 25. a–c: *"Chonetes" foedus*; **a**, topotype NMV P47600, latex from ventral external mould; **b**, holotype NMV P60871, ventral internal mould; **c**, paratype NMV P47601, latex from dorsal external mould. Dead Bull Member, Tabberabbera Formation; Pragian. Scale bars 5 mm.

Dorsal interior poorly known. Very fine median septum may reach valve midlength; anderidia fine, low, diverge at 35° or more, reaching ⅓ valve length. Muscle field obscure. Large elongate papillae aligned along impressions of coarser external ribs, absent from beneath externally smooth posterolateral areas; arrangement of papillae thus opposite of that in ventral valve.

Discussion. Talent could find no species with which to compare his material, and this remains the case. Johnson (1966: 366) commented "There remains some uncertainty regarding generic affinities ...", whereas Boucot & Johnson (1968) questionably assigned it to *Allanetes* on the basis of the similarity of the ribbing, quoting Talent's "... pronounced differentiation between the main body of the shell and the weakly ornamented posterolateral slopes". I agree with those authors that the ornament is not that of *Parachonetes*—in fact it is very distinctive, and also unlike that of *Allanetes*. In the latter, moreover, there are (unusually) a ventral fold and dorsal sulcus. Talent's species has a ventral sulcus, and a nearly flat dorsal valve. Unusual also is the depth of its body cavity, more like that of many productoids. It is likely that this species represents a new genus but, in view of the many gaps in present knowledge of its structure (e.g., spine type, presence or absence of a cardinal process pit), it would be premature to erect one.

Species rejected from the Chonetoidea

Chonetes bipartita Chapman, 1913

Chonetes bipartita Chapman, 1913: 104–105, pl. X, figs. 8–10.
Stropheodonta bipartita.–Gill, 1942: 41, pl. V, figs. 7, 9, pl. VI, figs. 8–10.
Plectodonta bipartita.–Gill, 1950: 249, pl. I, figs. 21–23.

Remarks. Gill (1942) recognised that Chapman's specimens were not a chonetoidean, but they were not finally referred to *Plectodonta* until after Brown (1949) redescribed the Yass species; the brief synonymy given above shows only the changes in generic position. Specimens assigned to *P. bipartita* have subsequently been described from a number of successions in southeastern Australia, but the original material has not been re-described or re-figured.

Chonetes concinna Chapman, 1904

Fig. 26a

Chonetes concinna Chapman, 1904: 223, pl. XXI, fig. 3.
Eoörthis concinna.–Chapman, 1917: 95.

Type material. HOLOTYPE NMV P26016 (formerly MDV 296), an internal mould of a dorsal valve from allotment 3i, section W, Parish of Knowsley, near Heathcote.

Stratigraphic distribution. Knowsley East Formation, Heathcote Greenstone Belt, central Victoria.

Age. *Ptychagnostus gibbus* Zone, Undillan, Middle Cambrian.

Discussion. Chapman thought in 1917 (but not 1904?) that the single small and poorly preserved specimen was a sulcate ventral valve. It is a dorsal valve, with a deep sulcus flanked by several plications. The hinge is close to the greatest width, and the interarea is narrow, anacline, divided by a wide notothyrium, and may be denticulate. The brachiophores are small plates diverging ventrally and also forwards, while the sockets are quite small. Nothing can be seen of the cardinal process or muscle field. In the absence of a ventral valve and details of the exterior, the specimen cannot reliably be placed even at the family level. As Chapman recognised, it is not a chonetoid.

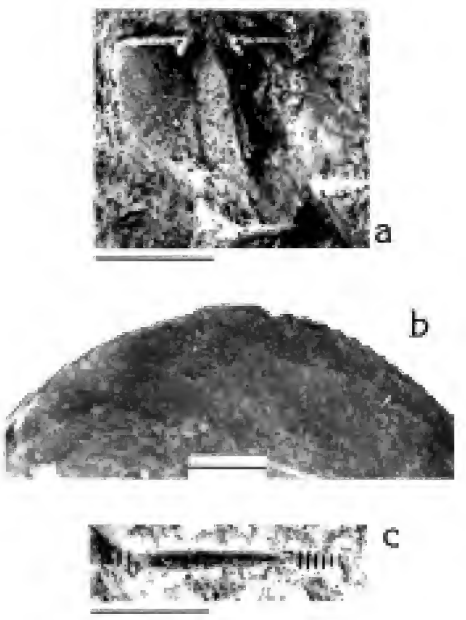

Figure 26. **a**: *Chonetes concinna*; holotype NMV P26016, latex from incomplete dorsal internal mould. Knowsley East Formation; Undillan (Middle Cambrian). **b,c**: *Chonetes (Chonetes) gaskini*; holotype NMV P123068; **b**, profile of shell, showing close resemblance to *Spinella buchanensis*—scale bar 5 mm; **c**, external mould of tentaculitid thought originally to be a corrugated hinge spine—scale bar 2 mm. Buchan Group; Emsian. Scale bar 2 mm.

Chonetes (Chonetes) gaskini Gill, 1945

Fig. 26b,c

Chonetes (Chonetes) gaskini Gill, 1945: 142, pl. VIII, figs. 9, 11.

Type material. HOLOTYPE NMV P123068 (formerly MUGD 1913) from the scarp along old Hut Creek, Bindi near Buchan, East Gippsland.

Stratigraphic distribution. Buchan Group, Buchan Rift, eastern Victoria.

Age. Emsian, Early Devonian.

Discussion. Described by Gill as a large incomplete ventral valve with a single annular hinge spine, the specimen is an incomplete spiriferid dorsal valve. As can be clearly seen by the profile figured here (Fig. 26b), there is a narrow flat fold, and numerous rounded lateral plications; it is probably *Spinella buchanensis* Talent, 1956. The "annular spine" is an adjacent tentaculitid (Fig. 26c).

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References

Afanas'yeva, G.A., 1996. Otryad Chonetida. *Trudy Paleontologicheskogo Instituta Rossiyskaya Akademiya Nauk* 266: 38–43.

Alekseyeva, R.E., 1967. *Brakhiopody i stratigrafiya nizhnego Devona severo-vostoka SSSR*. Moskva: Nauka.

Barrande, J., 1879. *Système Silurien du centre de la Bohême Pt. I, Recherches paléontologiques, v. 5, classe des Mollusques. Ordre des Brachiopodes*. Praha.

Bassett, M.G., 1977. The articulate brachiopods from the Wenlock Series of the Welsh Borderland and south Wales. *Palaeontographical Society Monograph* 130(4).

Bassett, M.G., 1979. Brachiopods. In *Lower Wenlock faunal and floral dynamics—Vattenfallet section, Gotland*, pp. 185–206. Sveriges Geologiska Undersökning C762.

Bassett, M.G., & L.R.M. Cocks, 1974. A review of Silurian brachiopods from Gotland. *Fossils and Strata* 3: 1–56.

Boucot, A.J., & K.L. Gauri, 1966. *Quadrikentron* (Brachiopoda), a new subgenus of *Strophochonetes*. *Journal of Paleontology* 40: 1023–1026.

Boucot, A.J., & C.W. Harper Jr, 1968. Silurian to lower Middle Devonian Chonetacea. *Journal of Paleontology* 42: 143–176.

Boucot, A.J., & J.G. Johnson, 1967. *Allanetes*, a new Lower Devonian chonetid brachiopod genus. *Proceedings of the Royal Society of Victoria* 80: 141–145.

Boucot, A.J., & J.G. Johnson, 1968. Brachiopods of the Bois Blanc Formation in New York. *United States Geological Survey Professional Paper* 584–B.

Brock, G.A., & J.A. Talent, 1993. Emsian (Early Devonian) brachiopods from the Ukalunda Beds and Douglas Creek, north Queensland. *Association of Australasian Palaeontologists, Memoir* 15: 225–248.

Bronn, H.G., 1862. *Die Klassen und Ordnungen der Weichthiere (Malacozoa)* 3(1). Leipzig & Heidelberg. [Not seen; *fide* Muir-Wood, 1962]

Brown, I.A., 1949. Occurrence of the brachiopod genus *Plectodonta* Kozlowski at Bowning, New South Wales. *Journal and Proceedings of the Royal Society of New South Wales* 82: 196–201.

Brunton, C.H.C., F. Alvarez & D.I. MacKinnon, 1996. Morphological terms used to describe the cardinalia of articulate brachiopods: homologies and recommendations. *Historical Biology* 11: 9–41.

Chapman, F., 1903. New or little-known Victorian fossils in the National Museum. Part II—some Silurian Molluscoidea. *Proceedings of the Royal Society of Victoria* 16: 60–82.

Chapman, F., 1904. On some brachiopods and a bivalve from Heathcote. *Records of the Geological Survey of Victoria* 1: 222–226.

Chapman, F., 1913. New or little-known Victorian fossils in the National Museum. Part 16. Some Silurian Brachiopoda. *Proceedings of the Royal Society of Victoria* 26: 99–110.

Chapman, F., 1917. The Heathcote fauna. *Records of the Geological Survey of Victoria* 4: 89–102.

Chatterton, B.D.E., 1973. Brachiopods of the Murrumbidgee Group, Taemas, New South Wales. *Bureau of Mineral Resources, Australia, Bulletin* 137.

Cocks, L.R.M., & J.-Y. Rong, 1989. Classification and review of the brachiopod superfamily Plectambonitacea. *British Museum of Natural History (Geology), Bulletin* 45: 77–163.

De Koninck, L.G., 1877. Recherches sur les fossiles paléozoïques de la Nouvelle-Galles du Sud (Australie). *Mémoires de la Société royale des Sciences de Liège, sér. 2*, 2. Translated by David *et al.*, 1898—*Geological Survey of New South Wales, Palaeontology Memoir* 6.

Douglas, J.G., & J.A. Ferguson, 1988. *Geology of Victoria.* Melbourne: Victorian Division, Geological Society of Australia Incorporated.

Dun, W.S., 1904. Notes on some new species of Palaeozoic Brachiopoda from New south Wales. *Records of the Geological Survey of New South Wales* 7: 318–325.

Flood, P.G., 1974. Lower Devonian brachiopods from the Point Hibbs Limestone of western Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 108: 113–136.

Garcia-Alcalde, J.L., & P.R. Racheboeuf, 1975. Données paléobiologiques et paléobiogéographiques sur quelques Strophochonetinae du Dévonien d'Espagne et du Massif Armoricain. *Lethaia* 8: 329–338.

Garratt, M.J., 1983. Silurian and Devonian biostratigraphy of the Melbourne Trough, Victoria. *Proceedings of the Royal Society of Victoria* 95: 77–98.

Garratt, M.J., & A.J. Wright, 1988. Late Silurian to Early Devonian biostratigraphy of southeastern Australia. In *Devonian of the World*, ed. N.J. McMillan, A.F. Embry & D.J. Glass, vol. 3, pp. 647–662. *Memoirs of the Canadian Society of Petroleum Geologists* 14.

Gill, E.D., 1942. The thickness and age of the type Yeringian strata, Lilydale, Victoria. *Proceedings of the Royal Society of Victoria* 54: 21–52.

Gill, E.D., 1945. Chonetidae from the Palaeozoic rocks of Victoria and their stratigraphical significance. *Proceedings of the Royal Society of Victoria* 57: 125–150.

Gill, E.D., 1949. Devonian fossils from Sandy's Creek, Gippsland, Victoria. *Memoirs of the National Museum of Victoria* 16: 91–115.

Gill, E.D., 1950. Preliminary account of the palaeontology and palaeoecology of the Eldon Group formations of the Zeehan area, Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* for 1949: 231–258.

Gill, E.D., 1951. Further studies in Chonetidae (Palaeozoic Brachiopoda) from Victoria. *Proceedings of the Royal Society of Victoria* 63: 57–72.

Gratsianova, R.T., & M.A. Rzhonsnitskaya, 1977. Ekologicheskiye osobennosti i znacheniye dlya korrelyatsii nekotorykh brakhiopod iz otlozheniy, prilegayushchikh k granitse mezhdu nizhnii i srednii devonom. *Trudy Instituta Geologii i Geofiziki, Sibirskoye otdeleniye Akademiya Nauk SSSR* 360: 37–51.

Hall, J., 1860. Descriptions of new species of fossils from the Silurian rocks of Nova Scotia. *Canadian Naturalist and Geologist* 5: 144–159.

Harper Jr, C.W., 1973. Brachiopods of the Arisaig Group (Silurian–Lower Devonian) of Nova Scotia. *Geological Survey of Canada, Bulletin* 215.

Havlíček, V., & P.R. Racheboeuf, 1979. Chonetacea (brachiopodes) du Silurien et du Dévonien de Bohême (Tchécosklovaque). *Annales de Paléontologie (Invertébrés)* 65: 69–138.

Isaacson, P.E., 1977. Devonian stratigraphy and brachiopod paleontology of Bolivia. Part A: Orthida and Strophomenida. *Palaeontographica, Abteilung A* 155: 133–192.

Jin, J., W.G.E. Caldwell & B.S. Norford, 1993. Early Silurian brachiopods and biostratigraphy of the Hudson Bay lowlands, Manitoba, Ontario, and Quebec. *Geological Survey of Canada, Bulletin* 457.

Johnson, J.G., 1966. *Parachonetes*, a new Lower and Middle Devonian brachiopod genus. *Palaeontology* 9: 365–370.

Johnson, J.G., 1970. Great Basin Lower Devonian Brachiopoda. *Geological Society of America, Memoir* 121.

Kemežys, K.J., 1965. New criteria for an Order of brachiopods. *Journal of Paleontology* 39: 505–506.

Kemežys, K.J., 1967 (unpubl.). *Studies in fossil brachiopod morphology.* PhD thesis, Australian National University, Canberra.

Lenz, A.C., & B.D. Johnson, 1985. Brachiopods of the Garra Formation (Lower Devonian), Wellington area, New South Wales, Australia: Orthida, Strophomenida, Pentamerida. *Palaeontographica, Abteilung A* 188: 35–70.

Lindström, G., 1861. Bidrag till kännedomen om Gotlands brachiopoder. *Öfversigt af kungliga Vetenskaps-Akademiens Förhandlingar, Stockholm* for 1860, 17: 337–382. [Not seen; *fide* Jin *et al.*, 1993]

Mansuy, H., 1912. Contribution à la géologie du Tonkin. Paléontologie. *Service Géologique de l'Indochine, Mémoires* 1(4): 55–71, 10–13 [not seen; *fide* Racheboeuf & Thanh (in press)]

Mawson, R., J.A. Talent, V.C. Bear, D.S. Benson, G.A. Brock, J.R. Farrell, K.A. Hyland, B.D. Pyemont, T.R. Sloan, L. Sorentino, M.I. Stewart, J.A. Trotter, G.A. Wilson & A.G. Simpson, 1988. Conodont data in relation to resolution of stage and zonal boundaries for the Devonian of Australia. In *Devonian of the World*, ed. N.J. McMillan, A.F. Embry & D.J. Glass, vol. 3, pp. 485–527. Calgary: *Canadian Society of Petroleum Geologists Memoir* 14.

Mawson, R., J.A. Talent, G.A. Brock & M. Engelbretsen, 1992. Conodont data in relation to sequences about the Pragian-Emsian boundary (Early Devonian) in south-eastern Australia. *Proceedings of the Royal Society of Victoria* 104: 23–56.

McCoy, F., 1876. *Prodromus of the Palaeontology of Victoria; Or, Figures and Descriptions of Victorian Organic Remains, Decade 4.* Melbourne: Geological Survey of Victoria.

Morris, J., & D. Sharpe, 1846. Description of eight species of brachiopodous shells from the Palaeozoic rocks of the Falkland Islands. *Quarterly Journal of the Geological Society, London* 2: 274–278. [Not seen].

Muir-Wood, H., 1962. *On the morphology and classification of the brachiopod suborder Chonetoidea.* London: British Museum of Natural History.

Öpik, A.A., 1953. Lower Silurian fossils from the *"Illaenus* Band", Heathcote, Victoria. *Geological Survey of Victoria, Memoir* 19.

Packham, G.H., 1968. *Monograptus* cf. *ultimus* Perner and *Monograptus formosus* Bouček from the Hume Series of the Yass District, New South Wales. *Proceedings of the Linnean Society of New South Wales* 92: 217–221.

Philip, G.M., 1962. The palaeontology and stratigraphy of the Siluro-Devonian sediments of the Tyers area, Gippsland, Victoria. *Proceedings of the Royal Society of Victoria* 75: 123–246.

Racheboeuf, P.R., 1976. Chonetacea (brachiopodes) du Dévonien inférieur du Bassin de Laval (Massif Armoricain). *Palaeontographica, Abteilung A* 152: 14–89.

Racheboeuf, P.R., 1978. Révision de *Chonetes sarcinulatus* (v. Schlotheim, 1820) (Brachiopoda, Chonetacea) du Dévonien inférieur du Harz, Allemagne. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* 156: 338–352.

Racheboeuf, P.R., 1981. Chonétacés (brachiopodes) Siluriens et Dévoniens du sud-ouest de l'Europe (systématique - phylogénie - biostratigraphie - paléobiogéographie). *Société géologique et minéralogique de Bretagne, Mémoire* 27.

Racheboeuf, P.R., 1982. *Philippotia*, a new name for the Devonian brachiopod *Hemichonetes* Racheboeuf, 1981, non *Hemichonetes* Lee & Sun, 1980. *Journal of Paleontology* 56: 1024.

Racheboeuf, P.R., 1987. Upper Lower and Lower Middle Devonian chonetacean brachiopods from Bathurst, Devon and Ellesmere Islands, Canadian Arctic Archipelago. *Geological Survey of Canada, Bulletin* 375.

Racheboeuf, P.R., 1990. Les brachiopodes Chonetacés dans les assemblages benthiques Siluriens at Dévoniens. *Palaeogeography, Palaeoclimatology, Palaeoecology* 81: 141–171.

Racheboeuf, P.R., 1998. The Chonetoidean brachiopods. A revised and updated systematic and bibliographic catalogue. *Documents des Laboratoires de Géologie de Lyon* 148.

Racheboeuf, P.R., & F. Fuchs, 1988. Chonetacés (brachiopodes) du Dévonien d'Allemagne. 1ère partie: revision des espèces du Siegenien et de l'Emsien inférieur de l'Eifel, de la Vallée du Rhin, du Synclinal de la Moselle, du Taunas et du Bergisches Land. *Palaeontographica, Abteilung A* 200: 163–188.

Racheboeuf, P.R., & P.J. Lespérance, 1995. Revision of Silurian and Devonian Chonetoidean brachiopods from Québec and northern New Brunswick (Canada). *Documents des Laboratoires de Géologie de Lyon* 136.

Racheboeuf, P.R., & T.-d. Thanh (in press). Lower Devonian chonetoidean brachiopods from Bac Bo, North Viêt Nam. *Palaeontology*.

Renaud, A., 1942. Le Dévonien du Synclinorium médian Brest-Laval. *Mémoires de la Société géologique et minéralogique de Bretagne*, 7(1), *Stratigraphie*, 1–184, fasc. 2, *Paléontologie* 1–439. [Not seen, *fide* Racheboeuf, 1998].

Rickards, R.B., & A.C. Sandford, 1998. Llandovery-Ludlow graptolites from central Victoria: new correlation perspectives of the major formations. *Australian Journal of Earth Sciences* 45: 743–763.

Savage, N.M., 1974. The brachiopods of the Lower Devonian Maradana Shale, New South Wales. *Palaeontographica, Abteilung A* 146: 1–51.

Schlotheim, E.F. von, 1820. *Die Petrefaktenkunde auf ihrem jetzigen Standpunkte durch die Beschreibung einer Sammlung versteinerter und fossiler überreste der Tier- und Pflanzenreichs der Vorwelt erläutert*, I. Gotha. [Not seen; *fide* Racheboeuf, 1998].

Sheehan, P.M., 1982. Late Ordovician and Silurian of the eastern Great Basin, part 4. Late Llandovery and Wenlock brachiopods. *Milwaukee Public Museum Contributions in Biology and Geology* 50.

Sherwin, L., 1979. Late Ordovician to Early Devonian graptolite sequences in Australia. *Acta Palaeontologica Polonica* 24: 155–163.

Sherwin, L., 1995. Siluro-Devonian brachiopods from the Amphitheatre and Winduck groups (Cobar Supergroup), western New South Wales. *Association of Australasian Palaeontologists, Memoir* 18: 61–96.

Smith, R.E., 1980. Lower Devonian (Lochkovian) biostratigraphy and brachiopod faunas, Canadian Arctic Islands. *Geological Survey of Canada, Bulletin* 308.

Sowerby, J. de C., 1839. On the fossil shells of the Silurian rocks. In *The Silurian System. Founded on Geological Researches in the Counties of Salop, Hereford, Radnor, Montgomery, Caermarthen, Brecon, Pembroke, Monmouth, Gloucester, Worcester, and Stafford; With Descriptions of the Coalfields and Overlying Formations. Part 2, Organic Remains*, R.I. Murchison, pp. 608–644. [Not seen, *fide* Muir-Wood, 1962].

Sowerby, J. de C., 1842. Appendix. In *Description of Silurian fossils from the Rhenish Provinces*, E.J.A.D. d'Archiac & E. de Verneuil. Memoir on the fossils of the older deposits in the Rhenish Provinces. *Transactions of the Geological Society of London* 2(6): 408–410. [Not seen, *fide* Racheboeuf, 1998]

Strusz, D.L., 1982. Wenlock brachiopods from Canberra, Australia. *Alcheringa* 6: 105–142.

Strusz, D.L., 1984. Brachiopods of the Yarralumla Formation (Ludlovian), Canberra, Australia. *Alcheringa* 8: 123–150.

Strusz, D.L., 1996. Timescales 3. Silurian. Australian Phanerozoic timescales, biostratigraphic charts and explanatory notes, second series. *Australian Geological Survey Organisation Record* 1995/32.

Strusz, D.L., B.D.E. Chatterton & P.G. Flood, 1970. Revision of the New South Wales Devonian brachiopod *"Spirifer" yassensis*. *Proceedings of the Linnean Society of New South Wales* 95: 170–190.

Talent, J.A., 1956. Devonian brachiopods and pelecypods of the Buchan Caves Limestone, Victoria. *Proceedings of the Royal Society of Victoria* 68: 1–56.

Talent, J.A., 1963. The Devonian of the Mitchell and Wentworth Rivers. *Geological Survey of Victoria, Memoir* 24.

Talent, J.A., 1965. The Silurian and early Devonian faunas of the Heathcote district, Victoria. *Geological Survey of Victoria, Memoir* 26.

Walcott, C.D., 1884. Paleontology of the Eureka district. *United States Geological Survey Monographs* 8. [Not seen; *fide* Johnson, 1970].

Williams, A., C.H.C. Brunton & S.J. Carlson, with others, 1997. *Treatise on Invertebrate Paleontology, part H, Brachiopoda, revised*. Boulder & Kansas: Geological Society of America & University of Kansas Press.

Williams, G.E., 1964. The geology of the Kinglake district, central Victoria. *Proceedings of the Royal Society of Victoria* 77: 273–327.

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A Critical Review of the Types and Putative Types of Southern Asian Marine and Freshwater Fish Species in the Australian Museum Named by Francis Day

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ABSTRACT. Specimens representing 160 nominal species of fishes that were named by Francis Day were among the nearly 2000 specimens sent to the Australian Museum by Day in 1884. The type status of each of these specimens was evaluated in light of new evidence obtained from the archival papers of Edward Ramsay, the curator responsible for the acquisition of the Day collection. Of the 160 species, 141 are represented by at least one specimen that must be considered as a possible type. Approximately 126 of those species are represented by syntypes or possible syntypes, 1 by a lectotype, 2 by possible holotypes, 1 by a questionable type, and the remaining 11 by paralectotypes or possible paralectotypes. These numbers greatly exceed previous estimates of the number of types of Day's species housed in the Australian Museum and include species for which types are otherwise unknown. Among the types of Day's fishes are species from coastal marine environments from throughout southern Asia, as well as fresh and brackish water species from India, Pakistan, Afghanistan, and Myanmar.

FERRARIS JR., CARL J., MARK A. MCGROUTHER & KERRYN L. PARKINSON, 2000. A critical review of the types and putative types of southern Asian marine and freshwater fish species in the Australian Museum named by Francis Day. *Records of the Australian Museum* 52(3): 289–306.

Francis Day is the single most influential figure in the ichthyology of southern Asia. During the 24 year period of his study of Asian fishes (1865 to 1889), Day named 343 species of marine and freshwater fishes, based primarily on nearly 10,000 specimens (Whitehead & Talwar, 1976) that he obtained during nearly 20 years of intermittent field work in India and the surrounding region, which includes the area that today extends from Afghanistan to Myanmar.

Day's ichthyological pursuits, which were initially conducted in addition to his normal duties as a military surgeon, resulted in more than 50 scientific papers on southern Asian fishes, not included in which were several

papers on fish culture and numerous government reports on aspects of Indian fisheries. His work on southern Asian fishes culminated in a massive tome generally known as "*The Fishes of India*" (Day, 1875–78). The book was issued in four parts (Day, 1875, 1876a, 1877c, 1878), plus one supplement (Day, 1888b), over a 13 year period, and later re-issued in an abbreviated version (Day, 1889a,b). Even now, more than 100 years after the final instalment, *The Fishes of India* is regarded as the most comprehensive study of the fishes of southern Asia.

Towards the end of Day's study of southern Asian fishes, he began to sell parts of his collection. Details of the extent of the sale and the purchasers of Day's fishes can be found in Whitehead & Talwar (1976). The Australian Museum (AMS) purchased part of the collection in 1884. Although the British Museum received the largest fraction of Day's collection, the Australian Museum purchase is thought to represent the second most important fraction (after the Indian Museum, Calcutta [now Zoological Survey of India, (ZSI)]) of Day's collection in terms of the numbers of type specimens. As noted in Whitehead & Talwar (1976), the nucleus of the collection sent to the Australian Museum was a series of specimens representing 809 species that Day placed on exhibit at the 1883 Great International Fisheries Exhibition in London. A catalogue prepared for the exhibit (Day, 1883) included a list of species displayed. The exhibit was viewed by Edward Ramsay, then Curator of the Australian Museum and representative of New South Wales to the exhibition. After the exhibition, Ramsay communicated further with Day and arranged for the purchase of the collection. According to a purchase schedule in the Australian Museum archives, the terms of the sale were for Day to send "1000 species of fish from India and the Malay Archipelago, about 1500 specimens" to the Australian Museum for 200 pounds sterling.

As noted in Whitehead & Talwar (1976), the list of species in the Exhibition Catalogue (Day, 1883) does not indicate that any of the exhibited specimens of species described by Day are types. In contrast, the catalogue clearly notes that exhibited specimens of some of the species named by either Bleeker or Blyth were "one of the types" or some comparable phrase. The absence of any notation regarding Day species types comes in marked contrast to such notations in the Australian Museum's Annual Report for 1884 (Anon., 1885), in which the acquisition of the Day collection was announced. Therein, the announcement of the purchase of Day's collection is followed by a five-page list of fish species names. The list is nearly identical to that found in the Exhibition Catalogue, with a few additions and deletions to the species list (along with a few corrections). Most notably, however, the list in the annual report includes the word Type, italicized and in parentheses, after many of the species named by Day. Similarly, the term "co-type" follows many of the species named by Bleeker that were not listed as one of his types in the Exhibition Catalogue. Nearly always, those species names with the terms "type", "co-type", or the phrase "One of the types", were printed in small capital letters, whereas other species names are printed in lower case letters (after the initial capital letter of the generic name). There seems to be only two likely sources of this additional information. Either Day provided Ramsay with a list of species represented by types, or Ramsay gleaned the information from Day's publications (especially *Fishes of India*). Our examination of correspondence from Day to Ramsay uncovered a packing list of fishes sent to AMS, which is described below (see Materials and methods). This list is similar to that in the Exhibition Catalogue and does not provide any additional information regarding the type status of any of the specimens. No additional lists were found, but Ramsay's extensive archival materials may still hold such a list.

The significance of the source of this information is that the type status of specimens as listed in the Annual Report appears to have been carried over to the registration of specimens as types and their subsequent curation as such. This has been further carried into Gilbert Whitley's draft list of types at the Australian Museum, which formed the basis of Whitehead & Talwar's (1976) list of "possible types" of Day species.

It should be noted that two much smaller lists of additional specimens of Day's fishes, which apparently arrived at the Australian Museum in 1885 and noted in the annual report for that year (Anon., 1886), show similar annotations for species said to be represented by types. No packing lists of species were found among Ramsay's correspondence, so the source of this information cannot be considered to have been added at some later date.

Although it may not be possible to determine the original source of the claim that specimens at the Australian Museum represent types of Day's species, there is no clear evidence that they were based on information provided by Day. It became clear to us that some of the specimens listed as types were either not from the type locality, or were not of the correct size and, therefore could not be types. We chose to critically examine the status of specimens of Day species housed at the Australian Museum that were listed as types, to more carefully evaluate their actual status.

Early in the study, we discovered a specimen identified as *Callichrous pabo* (Hamilton), which was similar in appearance to the description of *Callichrous nigrescens* Day, and was from a locality consistent with the type locality of Day's species. No specimens identified as *Callichrous nigrescens* were listed in the Exhibition Catalogue or were sent to AMS. In the *Fishes of India*, the Day name was listed as a junior synonym of *C. pabo*. We suspected that the updated nomenclature in *Fishes of India* was applied to this specimen to make it, and all of the specimens placed in the Exhibition, consistent with the valid names in the book. Further research uncovered similar examples, so we decided to broaden our study to examine all species in which AMS received one or more specimens identified as species which included (in the *Fishes of India*) one of Day's species as a junior synonym. Each of these specimens was examined as a possible type of the Day species by comparing the type locality and, when provided in the original description, its size and colour pattern.

Thus, the objectives of this study were to evaluate the type status of all specimens from the Day collection that were listed as types in the 1884 Annual Report or the AMS Register, and to evaluate the possibility that other Day specimens not listed as types are, in fact, types or possible types of Day species.

Materials and methods

Collection documentation. Several sources were consulted during this study to establish the historical record of the transfer of the collection of fishes to AMS and to evaluate the claim of type status of the specimens. A summary of the most important documents is given here.

In the Australian Museum annual report for the year 1884 (Anon., 1885: 42), an announcement of the acquisition of the Day collection is followed by a five-page list of species. The species list is in the same order in which the names are encountered in *Fishes of India*. Each species name is followed by the author of the name and one or more locality descriptors. Usually, the locality is a single word but, in some cases, a short phrase is used. The word "Type.", in italics and enclosed in parentheses, follows most, but not all, species described by Day. Similar notations are given about the type status for species named by Bleeker and Blyth. The term "Type", as used in the list, was defined at the top of the first page of the list as follows: "*Type*, that these are certified to by Dr. Day being part of his original collection, and named by him."

Specimens received by the Australian Museum were recorded in a ledger-style Register. Prior to 1885, several different general registers were used for all objects in the Museum's collections. In 1885, a separate register was initiated for the ichthyology collection, with the registration number comprising a numeric string preceded by a capital letter "I" and a full stop. Most of the fishes from Day's collection were apparently assigned a registration number prior to ichthyology starting a separate lettering system, and nearly all Day specimens have a registration number beginning with a "B". The first registration of Day fishes was found to be B.3019, entered in July, 1884. A series of 35 specimens, apparently all stuffed specimens, were registered in sequential order. The bulk of the collection, the fluid preserved specimens, were entered into the "B" register in 1885 by J. D. Ogilby (Paxton & McGrouther, 1996), but some specimens were registered later in the "I" series. Registration of the stuffed specimens was rudimentary. In most cases, the scientific name of the species and "India" (or ditto marks) were the only data listed. A few entries included a more precise locality, but some lines in the register were completely blank. In contrast, the registration of the fluid collection contained more detailed locality information as well as an indication that certain specimens were types. The species names and locality information were the same as that found in the 1884 Annual Report, although the species were not listed in the same order. Specimens indicated as types in the annual report were noted as such in the register, and additional specimens were recorded as types in the register.

In the New South Wales State Library archives, Edward Ramsay's correspondence from Francis Day includes a 22 page printed list of fishes, entitled:

DIVISION LI.
SPECIMENS OF FISH FROM INDIA AND THE INDIAN OCEAN.
EXHIBITED BY
DEPUTY SURGEON-GENERAL FRANCIS DAY, F.L.S., F.Z.S.

This list appears to be either part of the proof sheet for the Exhibition Catalogue (Day, 1883; referred herein as the Catalogue), or an offprint (with different pagination) of that portion of the Catalogue. The Catalogue and the printed list found with Ramsay's correspondence are identical, except for the pagination. However, the list in the Ramsay archives was annotated, presumably in Day's hand, with additional species names, crossed-out species names and, on the left margin of some of the names, a numeral between 2 and 10. On the last page there is a handwritten note, only partially legible but clearly signed by Day, in which Day certified that "seven hundred and eighty six species" were delivered to the New South Wales Commission. Thus, the list appears to be a packing list that Day prepared to accompany the shipment of specimens. The handwritten numeral indicates the number of specimens shipped, for those species represented by more than one specimen (the entry for one species states "many" rather than a definite number). This annotated packing list was clearly the basis of the list produced in the 1884 Annual Report. However, the packing list did not indicate type status of Day's species (although some species were said to be types of either Bleeker or Blyth species). A photocopy of the packing list is now in the AMS Ichthyology Section files.

At some time, a systematic cross index of the AMS collection was prepared on three inch by five inch index cards. The cards for the Day collection appear to have been prepared by one person, as the handwriting is distinctive and identical. The handwriting does not match that of the labels in the jars (see below) or that in the register. Each card included the name and locality of the specimen, the registration number, and a type indication. All of these data appear to be identical to the information in the register, and the cards may have been generated directly from the register. However, the cards also include the size of the specimens, which was not found in the register or in any of the early jar labels. Some of the cards contain annotations in different handwriting: primarily re-identifications. The card file was used by us in several ways. We were able to determine whether a specimen was registered in a different part of the register, the originally recorded size of the specimens, and redeterminations of specimens that were not listed as types.

Another source of information about the Day specimens was the labels inside jars. Several types of labels were found associated with specimens from Day's collection. Some labels defy classification, but most can be placed into one of relatively few groups. In order of decreasing significance, the label types are:

1 *Original specimen label, type 1* (Fig. 1): This label appears to be the one that accompanied the specimen when it was transferred from Day to AMS. The label is characterized by being of small size (approximately 20 by 30 mm), on thin paper, and with two solid horizontal lines, one running above and one below the middle of the label. In between the lines, in a small neat script, is written the scientific name and an abbreviated locality for the specimen (usually one word). The writing was often faded, but usually readable.

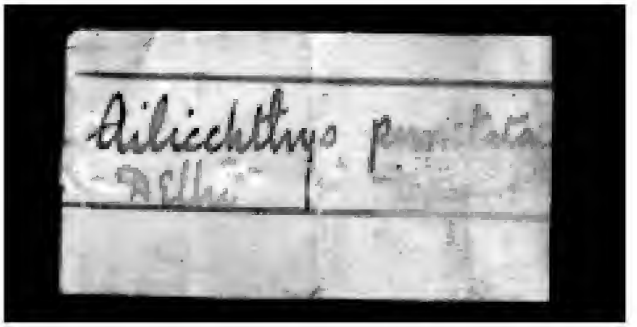

Figure 1. Original Specimen label Type 1. *Ailiichthys punctata* AMS B.7570.

Original specimen label, type 2 (Fig. 2): This label appears to have been an alternate label to the type 1 label, as the two were not found together in any jar. This label is characterized by its small size (about 20 by 40 mm), with three dotted horizontal lines that are approximately equally spaced from top to bottom across one side of the label. The script is small, but of a different style from that of the type 1 label. Writing was found above the middle and lower lines. However, the writing is badly faded, and in many cases there is virtually nothing left to read. When readable, it appears that the information is the same as that of the type 1 label; i.e., the scientific name and a one-word locality. These labels were either torn or there are signs of tiny holes in one corner of the label, suggesting that the label was initially sewn to the specimen. No specimens were found, however, with labels of this type sewn on.

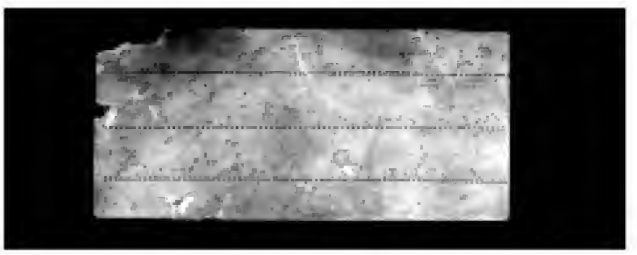

Figure 2. Original Specimen label Type 2. *Glyptosternum madraspatanum* AMS B.8004.

2 *Copy of the original specimen label* (Fig. 3): This label appears to be intended as an enlarged copy of the original label. The type and quality of the paper for this second label varies, but is usually an elongate piece of white paper of about 25 by 100 mm. The information is written in pencil in a script that is different from, and much larger than, that of either original label. This kind of label was either rolled up into a cylinder and tied with a fine thread, or wrinkled as if it had previously been tied up and now partially or completely unrolled. In some cases, the rolled-up label also had a metal tag bearing an impressed AMS registration number tied together with it (in some other specimens, the metal tag was tied directly to the fish, usually through the lower jaw). In a few instances, an original label, of either type 1 or type 2, was also found rolled up within the rolled-and-tied copy. The label contains the scientific name, one-word locality, and in addition, the author of the name. The text of this type of label was almost always readable, because of the size of the script and the use of pencil. This type of label appears to have been written at the time that the specimen was registered. This is inferred by the presence of labels with metal tags joined together. It is not likely that the tags were issued first, then removed from some specimens and attached to the paper labels. In addition, as will be noted below, subsequent labels usually include the registration number, and the absence of this information suggests that the number was not previously assigned.

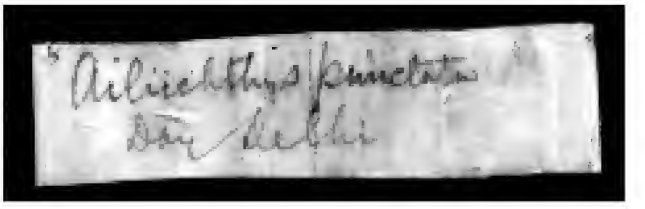

Figure 3. Copy of the Original specimen label. *Ailiichthys punctata* AMS B.7570.

3 *Jar label(s)* (Fig. 4): Most jars have one or more handwritten labels that appear to have been intended as a jar label, i.e., a label meant to be readable through the specimen container. These labels were written in pencil, and they appear to have been written by the same hand as the rolled-up copy (label 3, above). However, the paper was not folded or rolled. The information on the label varied. In many cases, only the scientific name of the specimen was written. In others, the registration number, author of the name, and an indication that the specimen was a type were variably included. It is possible that this category represents several generations of labels, but only rarely was more than one such label found together in a jar.

4 *Subsequent jar labels:* A variety of preprinted label forms, filled out in pencil, India-ink pen, or type-written (or a combination of media) exists in various combinations. In addition, computer-generated labels were prepared for all containers within the past decade. These labels often include information beyond that found in the early specimen labels or in the register, including changes in specimen

Figure 4. Jar label. *Ailiichthys punctata* AMS B.7570.

identification, updated localities, etc., most of which was not relevant to the question of whether the specimens represent types.

Identification of specimens as types. Because Day did not clearly identify specimens as types of his species, subsequent attempts to do so, such as ours herein, must be based on evidence that Day examined the specimen and considered it to be a member of his new species prior to its description. The criteria we used are as follows. Any specimen sent to AMS that arrived identified as a Day species was considered as a potential type of that species. In addition, any specimen that was identified as a valid species in Day's *Fishes of India* which included in its synonymy a species named by Day was considered as a potential type of the synonymized species. Each of the specimens that fit one of the two criteria mentioned above was compared against the locality and size of specimens examined in the original description. In many cases, Day was vague about the type locality of his species. When a specimen was found to have come from a locality that was consistent with a vaguely-worded type locality, we attempted to determine whether Day had visited (or received specimens from) the specimen locality prior to the publication of the species description. Finally, specimens were compared to the species account and illustration in the original description and the account in the *Fishes of India* for obvious discrepancies. More detailed comparison between the description and specimens was beyond the scope of this study. A specimen found to be consistent with the locality, collection date, size and description was listed below as a type. Most often, Day's species were described from a series of specimens, without an explicit holotype designation. We did not make an exhaustive search of the literature to determine whether lectotypes were designated for these species and, instead, referred to these specimens as syntypes unless we were aware of a valid lectotype designation. We did not attempt to verify all lectotype designations reported in Eschmeyer (1998), but we did list an AMS specimen as a paralectotype if Eschmeyer listed another specimen as the lectotype.

In a few cases, a specimen that fits our criteria for inclusion as a type increased the number of specimens claimed as possible types (Whitehead & Talwar, 1976) beyond the number of specimens stated in the original description of the species. In these cases, we referred to the specimen as a possible type and discussed the issue in the remarks.

All specimens considered by us as potential types are listed below, even if they were later determined not to qualify as types. It is possible that we misinterpreted the relationship between the stated type locality and the locality given for the specimen, and that a specimen rejected by us as not having come from the type locality may indeed qualify. Similarly, specimens not found by us during this study are listed below, as our search of the AMS collection was an extensive, but not an exhaustive one.

Data presentation. Species accounts are listed alphabetically by species name, similar to that in Eschmeyer (1998). For each of the species discussed, the following information is presented. The species name is the original spelling of the name, except that capital letters of the specific name have been changed to lower case. If a subgeneric name was used in the heading of the species account, that name is included. A subgeneric name mentioned elsewhere, either in the body of the species account or elsewhere in the text, is not added. The year of the original description follows Eschmeyer (1998) and details on the precise date of publication may be found therein. Type locality is stated exactly as given in the original description. When necessary for clarity, additional information about the type locality that was found elsewhere in the paper is added in brackets. The AMS registration number is given, followed by the number of specimens and size, or range of sizes, in parentheses, for each registration number. Specimen sizes are reported as standard length, in millimeters, except that total length (TL) is used for eels and sharks. Specimens that do not have a length were either not found during this study, or were on loan. We often repeat the size of the specimen(s) reported in the original description of the species for comparison with the AMS specimen(s). Early on, Day (1865c) stated that he reported the size of fish as total length, in inches and fractions thereof. Subsequently, he did not clearly state his measurement technique, but we think he continued to use total length throughout his career. The locality for each specimen is taken from specimen labels, when possible, or from the register. Localities stated in bold face are those taken from the original specimen label or the copy of that label (see Materials and methods for details). The section entitled Remarks include our interpretation of the type status of the specimen(s), as well as interpretations in published accounts of the specimens. Published comments on the status of the species name are included when the AMS specimen was among the specimens examined. A more extensive summary of the status of many of the species' names can be found in Eschmeyer (1998).

Results

Specimens of 102 species of fishes that were described by Francis Day were reported to be represented in the collection of the Australian Museum (Whitehead & Talwar, 1976). In addition, our search of the literature indicated that specimens that might represent unrecognized types of an additional 57 species were registered at AMS. During this study, specimens were found for all but 11 of these species. Three of the remaining 11 species were recorded in the 1884

Annual Report as having been received by AMS, but the specimens appear never to have been registered. This suggests either that they never actually were sent to the Museum, or they arrived but were overlooked. One of the missing 11 specimens was recorded in the register as having been considered lost in 1930. The fate of the remaining seven specimens is unclear.

The list below represents all species described by Day for which AMS has at least one specimen, or for which a specimen was listed by Day in his packing list. Of the 160 species listed, we concluded that 143 are represented by at least one type specimen. One of those species is represented by a lectotype, 127 by syntypes or possible syntypes, 3 by possible holotypes and the remaining 12 by paralectotypes or possible paralectotypes. These numbers must be somewhat tentative, however, as we did not make an exhaustive search of possible lectotype designations, and it is likely that some of the specimens we regard as syntypes are actually lectotypes or paralectotypes.

Arius acutirostris Day, 1877c: 459, pl. 107, fig. 1. Type locality: Salwein River at Moulmein in Burma. NON-TYPE: AMS B.7733 (1, 80 mm) **Irrawaddy**. Remarks: The AMS specimen has been considered a type following the notations in the 1884 Annual Report and the register. However, the specimen was not collected in the Salween River, the only locality mentioned in the original description. Therefore, the specimen cannot be considered to be part of the type series.

Pseudeutropius acutirostris Day, 1870d: 618. Type locality: Throughout Burma. SYNTYPE: AMS B.7967 (1, 79 mm) **Burma**. Remarks: Day reported that the species "rarely exceeds 4 inches" (101.6 mm), which is larger than the AMS specimen.

Salarias alboguttatus Day, 1876a: 334. Type locality: Andaman Is. SYNTYPE: AMS B.7497 (1) Andamans. Remarks: This name is preoccupied by *Salarias alboguttatus* Kner, 1867, and was replaced by *Salarias dayi* Whitley, 1929. Therefore, this specimen is also a syntype of Whitley's species. We were unable to locate this specimen.

Barbus ambassis Day, 1869a: 583. Type locality: Kurnool, in Madras, and Arcot. SYNTYPE: AMS B.7553 (1, 32 mm) Madras. Remarks: Day indicated that he examined specimens up to "2⅜ inches" (58.4 mm) in total length.

Arius andamanensis Day, 1871a: 699. Type locality: Andamans. SYNTYPE: AMS B.7931 (1, 187 mm) Andamans. Remarks: Subsequent to the description of this species, Day (1875–78) placed that name in the synonymy of *Arius thalassinus* (Rüppell). In his report on Andaman fishes, Day (1871a) did not list *A. thalassinus* among the species examined, which suggests that the only Andaman specimens of *A. thalassinus* he examined were his *A. andamanensis* types. The specimen arrived at AMS identified as *Arius thalassinus*, from the type locality of *A. andamanensis*. Kailola (1986: 546) identified this specimen as *Arius bilineatus* (Valenciennes, 1840), but she concluded that it was not conspecific with a specimen at ZSI also identified by Day as *A. andamanensis*.

Gobius andamanensis Day, 1871a: 691. Type locality: Brackish water in the Andamans. SYNTYPE: AMS B.8030 (1, 90 mm) Andamans. Remarks: Subsequent to the description of this species, Day (1875–78) placed that name in the synonymy of *Gobius puntang* Bleeker. The specimen deposited at AMS was identified by that name and listed as a co-type of Bleeker's species in the annual report (but not in Day's packing list). However, the specimen is from the type locality of *Gobius andamanensis* and should be considered as a syntype of that species.

Salarias andamensis Day, 1870c: 611. Type locality: Mundakhari Bay, Andaman Is. POSSIBLE SYNTYPE: AMS B.8062 (1) Andaman Is. Remarks: Day indicated that he examined four specimens. Springer & Williams (1994: 30) concluded that the type series was lost and designated a neotype (USNM 112032). However, they did not mention the AMS specimen and apparently did not know of its existence. The AMS specimen was not found during the course of this study.

Exostoma andersonii Day, 1870a: 524. Type locality: Hotham [=Hotha] and Ponsee, China. POSSIBLE SYNTYPE: AMS B.8081 (1, 127 mm) "Bhamo, China." Remarks: This specimen was cited in Day's packing list with the enigmatic citation: "*Exostoma andersonii* Do. Bhamo, China." The "Do." implies a repeat of the author of the previously listed species, which was *Pseudecheneis sulcatus* McClelland. However, *Exostoma andersonii* was described by Day, as noted above. In addition, the citation of "Bhamo, China" is peculiar inasmuch as, even during Day's time, Bhamo was a city of Upper Burma. Thus, it appears that the information about this species in Day's listing was not carefully edited. Anderson (1879) reported that the only specimens of this species taken during his two expeditions to Burma and China were the four on which Day based his description of *E. andersonii*, and Day (1875–78) did not indicate that he examined any additional specimens. Whitehead & Talwar (1976) indicated that only two of the original four specimens deposited at ZSI were found. Therefore, the specimen at AMS may well be one of Day's type specimens.

Barbus arenatus Day, 1878: 574, pl. 142, fig. 7. Type locality: Madras. SYNTYPE: AMS B.7906 (1, 82 mm) Madras. Remarks: Day was vague about the number of specimens examined. However, he clearly indicated that more than one specimen was studied, by the statement: "in some examples a darkish band... ."

Chela argentea Day, 1867a: 301. Type locality: Bowany River. PARALECTOTYPE: AMS B.7881 (1, 109 mm) Bowany. Remarks: Day reported that he examined specimens up to "5⅜ inches" (133.4 mm). See Eschmeyer (1998) for information on lectotype designation.

Panchax argenteus Day, 1868a: 706. Type locality: Near Madras. SYNTYPE: AMS B.7492 (1) Madras. Remarks: Subsequent to the description of the species, Day (1875–78) placed the name in the synonymy of *Haplochilus melastigma* (M'Clelland, 1839). The 1884 Annual Report lists *H. melastigma* from Madras among the species received from Day's collection. The AMS specimen was not found during this study, so it was not possible to determine whether it is within the "⅘ to 1⅒ inch" (20.3 to 30.4 mm) range listed by Day.

Macrones armatus Day, 1865b: 289, unnumbered fig. Type locality: Rivers and occasionally in backwaters, Cochin. NON-TYPE: AMS B.7573 (1, 76 mm) **Canara**. Remarks: Although this specimen was listed in the AMS register as a type of *Macrones armatus*, the locality associated with the specimen is remote from the stated type locality of the species. Day (1870f: 370) stated that he received specimens of *Macrones armatus* from Mangalore [South Canara] in 1870. It is likely that one of these specimens was sent to AMS.

Clarias assamensis Day, 1877c: 485. Type locality: Goalpara and as high as Suddya [Assam]. SYNTYPE: AMS B.7485 (1, 208 mm) **Assam**.

Perilampus aurolineatus Day, 1865b: 306. Type locality: In rivers and stagnant tanks [Cochin, India]. SYNTYPE: AMS B.7834 (1) Malabar. Subsequent to the description of the species, Day (1875–78) placed the name in the synonymy of *Danio malabaricus* (Jerdon). The locality of the specimen is vague, but represents a region that includes the type locality. However, the specimen is joined together by a string sewn through its mouth to a second specimen, AMS B.7835, from the Shevaroy Hills. The locality of this second specimen is outside of the region of Cochin and, therefore it cannot be considered a type. It is not possible to unambiguously associate a registration

number with either of these specimens as the metal tags are attached to the string and not to the specimens. There are no handwritten labels to refer to either. Therefore, it may not be possible to determine which of the two specimens is the syntype.

Barilius bakeri Day, 1865b: 305. Type locality: Mundikyum [Cochin, India]. NON-TYPE: AMS B.7916 (1, 87 mm) Travancore Hills. Remarks: Day indicated that he examined "several" specimens ranging from 4⁹⁄₁₀ to 5¹⁄₁₀ inches (116.8 to 129.5 mm) in total length. The locality listed for the specimen is the general region within which Mundikyum, the type locality, is found.

Rohtee bakeri Day, 1873b: 240. Type locality: Cottayam. POSSIBLE SYNTYPE: AMS (registration number unknown), Cottayam. Remarks: This species was listed in the 1884 Annual Report as having been received by AMS. However, we have not found a listing for the species in the register, card file, or database. Day indicated that he examined three specimens of this species, up to "4½ inches" (114.3 mm) in length. Whitehead & Talwar (1976) accounted for only one of the three specimens at ZSI.

Caranx bidii Day, 1873b: 237. Type locality: Madras. SYNTYPES: AMS B.8057 (2, 103–128 mm) Madras. Remarks: Subsequent to the description of this species, Day (1875–78) placed the name in the synonymy of *Caranx leptolepis* Cuvier (1833). The specimens sent to AMS were identified as *Caranx leptolepis*, from the type locality of *C. bidii*.

Apocryptes bleekeri Day, 1876a: 300, pl. 64, fig. 3. Type locality: Seas of India to the Malay Archipelago. SYNTYPE: AMS B.7501 (1, 58 mm) Madras. Remarks: Day (1873a: 109) initially identified specimens from Madras, Bombay, and Kurrachee as "*Apocryptes madurensis* ? Bleeker." He later concluded that his specimens were not conspecific with Bleeker's species and that they represented a new species (Day, 1876a). In the description of *A. bleekeri*, Day listed his account of *A. madurensis* (Day, 1873a) in the synonymy. Therefore, the specimens that were examined for the 1873 paper are part of the type series of *Apocryptes bleekeri*. As the specimen at AMS is from one of the localities listed in the 1873 paper, it is considered here to be one of the types. This specimen was identified by Murdy (1989: 9) as *Apocryptodon madurensis* (Bleeker, 1849).

Barilius (Pachystomus) bleekeri Day, 1872a: 5. Type locality: A river at Gangrete which joins the Beeas in the Sub-Himalayan range. SYNTYPE: AMS B.7827 (1, 97 mm), Kangra. Remarks: Subsequent to the description of this species, Day (1875–78) placed the name in the synonymy of *Barilius vagra* (Hamilton). The specimen sent to AMS was identified as *Barilius vagra*, and the stated locality of the specimen is a region that includes the type locality of Day's species.

Macrones bleekeri Day, 1877c: 451, pl. 101, fig. 1. Type locality: Originally "Sind, Jumna, upper waters of the Ganges, and Burma", now restricted by lectotype designation to Jumna River. PARALECTOTYPE: AMS B.7999 (1, 109 mm) **Seharunpore**. Remarks: The lectotype was designated in Roberts (1994), wherein the species was considered to be valid as *Mystus bleekeri*.

Scorpaena bleekeri Day, 1878: 747. Type locality: Andamans to Malay Archipelago. SYNTYPE: AMS B.8277 (1, 147 mm) Karachi. Remarks: Day illustrated this species, as *Scorpaena haplodactylus*, on pl. 36, fig. 2 of *Fishes of India* (Day, 1875). This name was proposed in the corrigenda of *Fishes of India* to provide a new name for the species previously described and illustrated as *Scorpaena haplodactylus* Bleeker (Day, 1875: 149, pl. 36, fig. 2), an identification that Day subsequently determined to be incorrect. Among the specimens received by AMS was one labelled *Scorpaena aplodactylus* from Batavia (AMS B.7729) which appears to correspond to a specimen mentioned in the 1884 Annual Report as a "type from Bleeker's collection." A second specimen identified as *Scorpaena aplodactylus*, from Karachi (AMS B.8277), is likely to be one of the specimens examined by Day in preparation of his account of *Scorpaena haplodactylus* Bleeker and, therefore, a part of the type series of *Scorpaena bleekeri*.

Chela boopis Day, 1874: 708. Type locality: South Canara. SYNTYPE: AMS B.7820 (1, 95 mm) Canara. Remarks: Day indicated that he examined specimens of this species up to "5 inches" (127 mm) in length.

Barbus bovianicus Day, 1877c: pl. 138, fig. 1 (text issued in Day, 1878: 566, as *Barbus bovanicus* [sic]). Type locality: Bowany River at base of Neilgherry hills in Madras (taken from Day, 1878: 566). SYNTYPE: AMS B.7829 (1, 98 mm) **Bowany**. Remarks: Day indicated that he examined specimens up to "5 inches" (127 mm) in length.

Semiplotus brevidorsalis Day, 1873b: 239. Type locality: Rivers below Neilgherry Hills, in the Madras Presidency. SYNTYPE: AMS B.7808 (1, 183 mm) Madras.

Otolithus brunneus Day, 1873c: 524. Type locality: Bombay. PARALECTOTYPES: AMS B.8193 (1, 173 mm) Bombay and B.8194 (1, 205) Bombay. Remarks: See Eschmeyer (1998) for information on the lectotype designation.

Amblyopus buchanani Day, 1873a: 110. Type locality: Calcutta. SYNTYPE: AMS B.7583 (1, 204 mm) Calcutta. Remarks: This specimen arrived at AMS identified as *Gobioides buchanani*, following the nomenclature in Day (1875–78). Day indicated that he examined specimens up to "11 inches" (279.4 mm) in length.

Cynoglossus buchanani Day, 1870a: 522. Type locality: no locality stated. POSSIBLE SYNTYPE: AMS B.7785 (1) Madras. Remarks: Subsequent to the description of this species, Day (1875–78) placed the name in the synonymy of *Cynoglossus hamiltonii* Günther. Day stated that he based his description on two specimens in the Calcutta Museum, but gave no information on the provenance of the specimens. This may indicate that there was no locality information associated with the specimens or that the locality was accidentally overlooked in Day's account. Whitehead & Talwar (1976) reported that the Register at the Zoological Survey of India indicates one missing lot (A 463) for that species, but they give no indication of whether more than one specimen was included in the lot. Thus, it is possible, but not likely, that the AMS specimen represents one of the two types of this species.

Nangra buchanani Day, 1877c: 494, pl. 113, fig. 3. Type locality: Ganges, Jumna, and Indus rivers; Delhi, India. SYNTYPE: AMS B.7541 (1, 44 mm) **Indus**. Remarks: It is not clear from the original description whether this name should be considered a new name, with its own types, or a replacement for *Pimelodus nangra* Hamilton, in order to avoid the tautonomy caused by Day's use of *Nangra* as a generic name. If it is a new name, the specimen noted above should be considered a type.

Dangila burmanica Day, 1877c: 546, pl. 131, fig. 2. Type locality: Moulmein and Tavoy. SYNTYPE: AMS B.7854 (1, 130 mm) Moulmein. Remarks: Day indicated that he examined specimens up to "10 inches" (254 mm) in length.

Olyra burmanica Day, 1872d: 711. Type locality: Pegu Yomas [Burma]. SYNTYPE: AMS B.7560 (1, 41 mm) Pegu. Remarks: Day indicated that he examined two specimens of this species. Whitehead & Talwar (1976) did not uncover the second specimen in any of the museums they surveyed.

Arius burmanicus Day, 1870d: 618. Type locality: Irrawaddi, Bassein district, and Salwein in the Tenasserim provinces. SYNTYPE: AMS B.7520 (1, 270 mm) **Moulmein**. Remarks: Moulmein is a large city at the mouth of the Salween River. Day did not provide any indication of the number or the size of the specimens examined.

Barbus burmanicus Day, 1878: 572, pl. 141, fig. 4. Type locality: Burma, the example (figured life size) was from Mergui. POSSIBLE SYNTYPE: AMS B.7898 (1, 104 mm) Pegu [Burma]. Remarks: This specimen was not listed as a type in the 1884

Annual Report, but it was so listed in the register. The stated type locality of the species is not very informative, except that it appears that Day found the species in more than one place in Burma. The locality of the AMS specimen is among the Burmese localities visited by Day (1870d).

Eleotris canarensis Day, 1876a: 313, pl. 69, fig. 2. Type locality: Mangalore. SYNTYPE: AMS B.8271 (1) Canara. Remarks: The stated locality of this specimen is a region within which Mangalore, the type locality of the species, is found.

Etroplus canarensis Day, 1877c: 414, pl. 89, fig. 5. Type locality: South Canara. SYNTYPE: AMS B.8148 (1, 63 mm) **Canara**. Day indicated that he examined specimens "to at least 4½ inches" (114.3 mm) in length.

Apocryptes cantoris Day, 1871a: 693. Type locality: Andaman Is. NON-TYPE: AMS B.8336 (1, 46 mm) Madras. Remarks: This specimen arrived at AMS identified as *Apocryptichthys cantoris*, following the nomenclature in Day (1875–78). It has been listed in the register as a type, but the stated locality for the specimen does not match the type locality. Therefore, this specimen should not considered to be part of the type series.

Nemacheilus chryseus Day, 1873c: 529. Type locality: Bowany River. SYNTYPE: AMS B.7489 (1, 36.8 mm) Bowany. Remarks: Subsequent to the description of this species, Day (1875–78) placed the name in the synonymy of *Nemachilus* [sic] *beavani* Günther. The specimen was sent to AMS identified as *Nemachilus* [sic] *beavani* from the type locality of *Nemacheilus chryseus*.

Pseudobagrus chryseus Day, 1865b: 290. Type locality: Kurriavanoor River; backwater at Kurriapudnam and river at Cochin, India. POSSIBLE SYNTYPE: AMS B.7922 (1, 175 mm) Malabar. Remarks: The specimen received at AMS was identified as *Macrones chryseus*, following the nomenclature in Day (1875–78) and listed as a type specimen in the register. Day (1865b) lists several localities from which he saw specimens, and stated that the species was "exceedingly common". However, Day's account implies that only one specimen was examined, as he stated that the "length of specimen 6⅖ inches" (157.5 mm) and the proportional measurements were not presented as ranges of values. Eschmeyer (1998) concluded that only one specimen was studied, which would make that specimen the holotype. The specimen at AMS is too small to be the measured specimen. It is therefore either a syntype or, if the measured specimen is a holotype, not a type.

Serranus coromandelicus Day, 1878: 746. Type locality: Seas of India to the Malay Archipelago. SYNTYPE: AMS B.8272 (1, 270 mm) **Madras**. Remarks: This name is a replacement for *Epinephelus dayi* Bleeker, 1875, which is preoccupied by *Epinephelus dayi* Bleeker, 1873. Bleeker (1875: 47) proposed a new name for the species described and illustrated in Day (1875: 12, pl. 8, fig. 1) as *Serranus waandersi* Bleeker. Therefore, the types of *Epinephelus dayi* Bleeker, 1875, and its replacement, *Serranus coromandelicus*, are all of the specimens that Day considered in the preparation of his account of *Serranus waandersi*. Day's account of *Serranus waandersi* clearly indicates that more than one specimen was examined, as a range of body and eye proportions and lateral line scale counts are given. Therefore, the *Serranus coromandelicus* must be considered to have been based on a series of syntypes and not, as Randall & Heemstra (1991) and Eschmeyer (1998) concluded, a holotype. The 1884 Annual Report lists *Serranus coromandelicus* as a species received from the Day collection and must be considered a syntype.

Euctenogobius cristatus Day, 1873a: 109. Type locality: Bombay and Madras. SYNTYPE: AMS B.8198 (1, 90 mm) Bombay. Remarks: Day indicated that he examined specimens of this species up to "5 inches" (127 mm) in length, but did not specify the number of specimens in his possession.

Chrysophrys cuvieri Day, 1875: 141, pl. 34, fig. 3. Type locality: Seas of India. SYNTYPE: AMS B.8225 (1, 129 mm) **Madras**. Remarks: Day did not indicate how many specimens he examined, but reported that the largest specimen was "14½ inches" (368.3 mm) in length. He gave no indication of the provenance of his specimens, except that the figured specimen was from Mangalore. Thus, we base our conclusion on the type status of this specimen on the original identification label.

Labeo denisonii Day, 1865b: 299. Type locality: Mundikyum. SYNTYPE: AMS B.7913 (1, 89 mm) Travancore Hills. Remarks: This specimen was received at AMS identified as *Barbus denisonii*, following the nomenclature in Day (1875–78). Day indicated that he examined several specimens for the description of this species, ranging from 4 to 5⅒ inches (101.6 to 129.5 mm) in total length. The stated locality for the specimen is the general region within which Mundikyum, the type locality, is found.

Nemacheilus denisoni Day, 1867a: 287. Type locality: Bowany River. NON-TYPE: AMS B.7507 (1, 57 mm) Wynaad. Remarks: Apparently Day received specimens from the Wynaad only after the description of this species (Day, 1867b).

Cynoglossus dispar Day, 1877c: 434, pl. 96, fig. 2. Type locality: Bombay and Madras. NON-TYPES: AMS B.7941 (1) and AMS B.7942 (1) both from Sind. Remarks: The specimens noted here were listed as types in the 1884 Annual Report, but they were not collected in Bombay or Madras, the only localities which Day mentioned in his original description. Therefore, the specimens cannot be considered to be part of the type series.

Barbus (Barbodes) dobsoni Day, 1876b: 574. Type locality: [Deccan, India]. SYNTYPE: AMS B.7860 (1, 62 mm) **Poona**. Remarks: No locality was stated in the account of this new species. The paper was concerned only with fishes of the Deccan, a region of India that includes Poona. The locality of the specimen sent to AMS is consistent with the inferred type locality of the species.

Puntius (Barbodes) dubius Day, 1867a: 291. Type locality: Bowany River. SYNTYPE: AMS B.7608 (1, 173 mm) Bowany. Remarks: This specimen was received at AMS identified as *Barbus dubius*, following the nomenclature in Day (1875–78). Day gave no indication of the number of specimens examined or their size.

Barbus dukai Day, 1878: 564, pl. 143, fig. 3. Type locality: Teesta River, Darjeeling. SYNTYPE: AMS B.7893 (1, 84 mm) Darjeeling. Remarks: Day was unclear about the number of specimens he examined and only indicated that he obtained "several examples" of this species.

Silurus dukai Day, 1873b: 239. Type locality: Darjeeling. SYNTYPE: AMS B.7571 (1, 87 mm) **Darjeeling**. Remarks: Subsequent to the description of the species, Day (1875–78) placed the name in the synonymy of *Silurus afghana* Günther. The specimen arrived at AMS identified as *Silurus afghana* from type locality of *Silurus dukai*.

Callichrous egertonii Day, 1872d: 710. Type locality: Sub-himalayan range in the Punjaub. SYNTYPE: AMS B.8065 (1, 146 mm) **Sind**. Remarks: Subsequent to description of this species, Day (1875–78) placed that name in the synonymy of *Callichrous pabda* (Hamilton). The specimen arrived at AMS identified as *C. pabda*. The locality given for the specimen is vague, but it is consistent with the stated type locality of the species.

Apogon ellioti Day, 1875: 63, pl. 17, fig. 1. Type locality: Originally "east coast of Africa to China and Japan", restricted to Madras by lectotype designation. POSSIBLE LECTOTYPE OR PARALECTOTYPE: AMS B.8226 (1, 60 mm) **Madras**. Remarks: Day indicated that he examined two specimens "up to 4 inches" (101.6 mm) in length, but Whitehead & Talwar (1976) recorded a total of four putative types of this species, in the collections of ZSI, AMS, and RMNH. Gon (1997: 188) selected the

"illustrated specimen" as lectotype, and followed Whitehead & Talwar's (1976) statement that the illustrated specimen was one of the two specimens at ZSI. From the text of Gon's paper it is not clear whether he examined the ZSI specimens and compared them to the published illustration, or based his conclusion solely on Whitehead & Talwar. Because of this, we consider the question of which of the four potential types is actually the lectotype to be unresolved.

Solea elongata Day, 1877c: 426, pl. 90, fig. 4. Type locality: Madras. POSSIBLE SYNTYPES: AMS B.8278–79 (2, 34–48 mm) Madras. Remarks: Day stated that he examined only two specimens when he described this species. The 1884 Annual Report lists *Solea elongata*, from the type locality, among the included species. However, Whitehead & Talwar (1976) report three specimens from the Day collection at ZSI (now all lost). Thus, the type status of the specimens at AMS is uncertain.

Barilius evezardi Day, 1872b: 326. Type locality: Púna. POSSIBLE SYNTYPE: AMS B.7895 (1, 93 mm) Poona. Remarks: Day indicated that he examined three specimens of this species, up to "4½ inches" (114.3 mm) in length. Whitehead & Talwar (1976) indicated that at least five museums possess specimens of this species from Day's collection.

Upeneoides fasciolatus Day, 1868c: 151. Type locality: Madras, India. POSSIBLE SYNTYPE: AMS B.8186 (1, 120 mm) **Madras**. Remarks: Subsequent to the description of this species, Day (1875–78) placed the name in the synonymy of *Upeneoides sulphureus* (Cuvier, 1829). The specimen mentioned above was sent to AMS identified as *U. sulphureus* from the type locality of *Upeneoides fasciolatus*. However, in the original description of the species, Day provided the following statement: "Length of specimen 3 inches" (76.2 mm). This may indicate that Day had only one specimen, as was concluded in Eschmeyer (1998), or that the best or largest specimen was that size. The specimen at AMS is substantially larger than 3 inches (76.2 mm) and therefore, not the specimen referred to by Day. However, because the specimen came from the type locality, and as Day did not indicate clearly whether he had only one specimen, we cannot exclude it from consideration as a part of the type series, and instead, list it as a possible syntype.

Boleophthalmus glaucus Day, 1876a: 306, pl. 65, fig. 3. Type locality: Andamans. SYNTYPE: AMS B.8121 (1, 128 mm) **Andamans**. Remarks: This specimen was not indicated as a type in the 1884 Annual Report. Murdy (1989: 50) identified the specimen as *Scartelaos cantoris* (Day, 1871a) and placed *Boleophthalmus glaucus* in the synonymy of that species.

Sciaena glaucus Day, 1876a: 192, pl. 46, fig. 2. Type locality: Seas of India. SYNTYPES: AMS B.8236 (1, 133 mm) and B.8237 (1, 81 mm), both from Malabar. Remarks: Day did not provide details of the provenance of his specimens, except to say that the species was common at Bombay, and that a variety of the species was found in the Andamans and Orissa. Day listed his account of *Sciaena dussumieri* from Malabar (Day, 1865c) in the synonymy of the new species. It is possible that the specimens at AMS are the specimens he examined at that time.

Genyoroge grammica Day, 1871a: 679. Type locality: Andaman Is. SYNTYPE: AMS registration number unknown (1) Andamans. Remarks: Subsequent to the description of this species, Day (1875–78) placed the name in the synonymy of *Lutianus quinquelinearis* (Bloch). Day's packing list and the 1884 Annual Report list *L. quinquelinearis*, from the Andamans, among those shipped to AMS. However, no specimen identified as *Lutianus quinquelinearis*, *L. quinquelineatus*, or *Genyoroge grammica* from the Day collection was found in the AMS collection, and we have been unable to find an appropriate entry in the register. Thus, it is uncertain whether a specimen of this species was actually received by AMS.

Sicydium griseum Day, 1877a: 140. Type locality: South Canara. SYNTYPE: AMS B.8254 (1, 62 mm) **Canara**. Remarks: Day indicated that he examined two specimens, of up to "3 inches" (76.2 mm) in length. Whitehead & Talwar (1976) reported a second specimen of this species at ZSI.

Gobius griseus Day, 1876a: 285, pl. 63, fig. 3. Type locality: Madras, in the backwaters. SYNTYPE: AMS B.8300 (1, 38 mm) Madras.

Barbus guentheri Day, 1869a: 582. Type locality: Hindree and Tamboodra rivers, Kurnool. NON-TYPES: AMS B.3039 (1, 135 mm, dry skin) Poona, India; AMS B.7518 (1, 160 mm) Deccan. Remarks: Subsequent to the description of this species, Day (1875–78) placed this name into the synonymy of *Barbus kolus* Sykes. The AMS specimens arrived identified as *Barbus kolus*. The register entry for the specimen labelled AMS B.3039 listed "Poona", which is repeated in a gallery label associated with the specimen. The total length of this specimen (approximately 6½ inches (165.1 mm), but caudal fin damaged) is larger than the range of sizes ("2 to 5⅗ inches" (50.8 to 134.6 mm)) listed for the species originally examined by Day. The locality associated with AMS B.7518 is vague, but north of the type locality of the species. In addition, the specimen is much larger than that stated for the types. Thus, neither specimen qualifies as a type.

Mastacembelus guentheri Day, 1865a: 37. Type locality: Paddyfields and Trichoor backwater [Cochin]. NON-TYPE: AMS B.8048 (1, 224 mm) Malabar. Remarks: This specimen was indicated in the register and in the 1884 Annual Report as a type, but in the description of the species Day (1865a) indicated that the specimens he examined ranged from 4⅘ to 7 inches (121.9 to 177.8 mm) in length. The largest specimen reported by Day is far shorter than the nearly 9 inch (228.6 mm) standard length of the specimen at AMS.

Opsarius guttatus Day, 1870d: 620. Type locality: Irrawaddi, from Prome to Mandalay. SYNTYPE: AMS B.8224 (1, 138 mm) Prome. Remarks: This specimen arrived at AMS identified as *Barilius guttatus*, following the nomenclature in Day (1875–78). Day indicated that he examined specimens up to "7 inches" (177.8 mm) in length.

Upeneoides guttatus Day, 1868b: 938. Type locality: Madras, India. SYNTYPE: AMS I.25 (1, 107 mm) **Madras**. Remarks: Subsequent to the description of this species, Day (1875–78) placed the name in the synonymy of *Upeneoides bensasi* (Temminck & Schlegel, 1843). The specimen at AMS was identified as *U. bensasi* and is from the type locality of *U. guttatus*. The size of the AMS specimen is consistent with the statement in the original description, which stated that the specimens examined by Day were up to "4⅞ inches" (119.4 mm) in length.

Mugil hamiltonii Day, 1870d: 614. Type locality: Irrawaddi, Pegu, and other rivers of Burma. SYNTYPE: AMS B.7993 (1, 81 mm) **Burma**. Remarks: Day indicated that he examined specimens of up to "4½ inches" (114.3 mm) in length. Thomson (1997: 497) identified this specimen as *Sicamugil hamiltoni*, but apparently did not consider it to be part of the type series.

Barbus (Barbodes) himalayanus Day, 1872b: 325. Type locality: Ussun River, about four miles from Simla. SYNTYPES: AMS B.7868 (2, 93–153 mm) Simla. Remarks: Day (1875–78) placed the name in the synonymy of *Barbus chilinoides* McClelland. The specimens that were sent to AMS were identified as *Barbus chilinoides*, from a locality that is vague, but consistent with the type locality of Day's species. Eschmeyer (1998) was in error in stating that the description was based on a single specimen. Day reported that five specimens were examined. These specimens represent a species of the genus *Tor* (Ferraris, pers. obs).

Crenidens indicus Day, 1873d: clxxxvi. Type locality: Kurrachi and Madras. SYNTYPE: AMS B.8216 (1, 235 mm) **Sind**. Remarks: Sind is the region of Pakistan that includes Karachi

(Kurrachi). Day gave no indication of the number of specimens of this species that he examined, but stated that the largest was "12 inches" (304.8 mm) in length.

Cubiceps indicus Day, 1871a: 690. Type locality: Madras. NON-TYPES: AMS I.108 (1, 91 mm), I.645 (1, 89 mm), and B.8114 (1, 35 mm, re-identified by J. Leis in 1996, as *Lutjanus* sp.), all from Madras. Remarks: These specimens were not indicated as types in the 1884 Annual Report, but the latter two (I.645 and B.8114) were so indicated in the register and card index. In his description of the species, Day (1871a) indicated that he had several specimens "up to 3 inches long" (76.2 mm). Two of the specimens listed here are over 4 inches (101.6 mm) in standard length, much larger than the maximum size indicated by Day. The third specimen (B.8114) is less than three inches (76.2 mm), but is clearly not a specimen that fits Day's description. Therefore, the indications in the register that these specimens represent types appear to be incorrect.

Saurus indicus Day, 1873c: 526. Type locality: Madras. NON-TYPE: AMS B.7672 (1, 210 mm) Madras. Remarks: Day indicated that he examined three specimens of this species, up to "7 inches" (177.8 mm) in length. Cressey (1981: 21) considered the AMS specimen to be as *Saurida tumbil* and not conspecific with the Leiden paralectotype, which he considered to be a specimen of *Saurus indicus*. See Eschmeyer (1998) for discussion about lectotype designation of this species.

Barilius interrupta Day, 1870b: 559. Type locality: Hotha [China]. SYNTYPE: AMS B.7745 (1, 46 mm) Hotha, Yunnan. Remarks: Day indicated that he examined specimens up to 2 inches (50.8 mm) in total length.

Scaphiodon irregularis Day, 1872b: 324. Type locality: Rivers in the Sind Hills, up to 3500 feet elevation, and Marrí. SYNTYPE: AMS B.7883 (1, 79 mm) Sind.

Barbus (Barbodes) jerdoni Day, 1870f: 372. Type locality: Mangalore. SYNTYPE: AMS B.7935 (1, 179 mm) Canara. Remarks: The locality stated for the specimen is the region of India that includes the city of Mangalore, the type locality of the species. Day did not indicate the number of specimens examined or the range of their lengths.

Garra jerdoni Day, 1867a: 288. Type locality: Seegoor and Bowany rivers. NON-TYPE: AMS B.7677 (1, 153 mm) **Bowany**. Remarks: This specimen was received at AMS identified as *Discognathus jerdoni*, following the nomenclature in Day (1875–78). Day reported that he examined specimens ranging from "2 to 4⅝ inches" (50.8 to 114.3 mm) in total length. The AMS specimen is too large to be part of the type series.

Mugil jerdoni Day, 1876a: 352. Type locality: Seas of India. SYNTYPE: AMS B.7983 (1, 118 mm) **Bombay**. Remarks: Day provided little information on the provenance of his type specimens. At least part of his type series came from the vicinity of Cochin, where he had previously identified the specimens as *Mugil sundanensis* (Day, 1865b). The AMS specimen is considered a type on the basis of the identification provided on the original label.

Brachygramma jerdonii Day, 1865b: 304. Type locality: Cochin, India. NON-TYPE: AMS B.7871 (1, 161 mm) Cochin. Remarks: Subsequent to the description of this species, Day placed the name in the synonymy of *Amblypharyngodon melettinus* (Valenciennes in Cuvier & Valenciennes, 1844). A specimen identified as *A. melettinus* from the type locality of *Brachygramma jerdonii* was sent to AMS by Day. The original specimen label and the copy of that label are both absent from the jar, but the specimen has a metal tag sewn to its lower jaw. However, the specimen is far larger than the "2⅜ to 3⅝ inches" (73.7 to 96.5 mm) that Day listed in the original description, and the specimen quite clearly does not match the description of this species. The Catalogue index card prepared for this species lists the size of the specimen as 4 inches (101.6 mm), which is about one half the total length of the specimen mentioned here. Thus, it appears that the specimen currently labelled as AMS B.7871 is not the specimen originally sent as *Amblypharyngodon melettinus* and cannot be considered a type of that species.

Mugil klunzingeri Day, 1888a: 264. Type locality: Red Sea and seas of India, and Bombay. SYNTYPES: AMS B.8078 (2, 104–109 mm) Bombay. Remarks: This name was based on the specimens first identified as *Mugil carinatus* in *Fishes of India* (Day, 1877c: 349, pl. 74, fig. 2), which Day later determined was not that species. The AMS collection has two specimens from the Day collection identified as *Mugil carinatus* from Bombay, which must be considered as a part of the type series of *Mugil klunzingeri*.

Pomacentrus labiatus Day, 1877c: 384, pl. 81, fig. 2. Type locality: Andamans and Nicobars. SYNTYPE: AMS I.149 (1, 57 mm) Andamans.

Trichogaster labiosus Day, 1877c: 374, pl. 79, fig. 4. Type locality: Burma, found in the Irrawaddi at Rangoon, and certainly as high as Mandalay. SYNTYPE: AMS B.7582 (1, 52 mm) **Burma**. Remarks: The locality given for the specimen is vague, but it is consistent with the type locality of the species.

Tetrodon leopardus Day, 1878: 706, pl. 180, fig. 2. Type locality: Seas of India. SYNTYPE: AMS B.7722 (1) **Madras**.

Glyphidodon leucopleura Day, 1877c: 385, pl. 83, fig. 4. Type locality: Andamans. POSSIBLE SYNTYPE: AMS I.95 (1, 22 mm) Andamans. Remarks: Day indicated that he examined two specimens during the preparation of this species account. A specimen identified as this species, from the type locality, was among those sent to AMS by Day. However, Whitehead & Talwar (1976) report that both ZSI and NMW possess a specimen from the Day collection. Thus, the type status of one or more of the three specimens mentioned above is in question.

Petroscirtes lienardi Day, 1876a: 327, pl. 69, fig. 8. Type locality: Sind. SYNTYPE: AMS B.7984 (1) Sind. This specimen is listed in the register as lost in 1930.

Euglyptosternum lineatum Day, 1877c: 500, pl. 116, fig. 7. Type locality: Jumna River and near Suddya in upper Assam. SYNTYPE: AMS B.7509 (1, 266 mm) **Suddya**. Remarks: The copy of the original label states "*Euglyptosternum striatum* Day". This appears to be a *lapsus calami*, either by Day or the person who transcribed Day's original label, for *Euglyptosternum lineatum* and not *Glyptosternum striatum*. *Euglyptosternum lineatum* was listed in Day's packing list as one of the species sent to AMS by Day; *Glyptosternum striatum* was not. The specimen referred to here is about 12½ inches (317.5 mm) in total length which, together with the locality listed on the label, appears to correspond to a specimen from Suddya mentioned specifically by Day in his description.

Barbus (Barbodes) lithopidos Day, 1874: 708. Type locality: South Canara. SYNTYPE: AMS B.8374 (1, 277 mm) **Canara**; POSSIBLE SYNTYPES: AMS B.3029 (1, 285 mm, dry skin), AMS B.3030 (1, apparently a dry skin, destroyed in 1909). Remarks: One specimen, AMS B.8374, was listed as a type in the register and card file and is from the type locality of the species. The register entries for the remaining two specimens have very rudimentary notations, and no indication that either specimen was a type. However, a gallery label prepared for AMS B.3029 states the locality of the specimen as "Southern Canara, Western India." Thus, it is possible that this specimen is part of the type series of the species. The status of the remaining specimen (AMS B.3030) is moot, as the register indicates that the specimen was destroyed in 1909.

Glyptosternum madraspatanum Day, 1873c: 526. Type locality: Bowany River, at the base of the Neilgherry Hills. POSSIBLE SYNTYPES: AMS B.7759 (1, 79 mm) Bowany and B.8004 (1, 107 mm) Bowany. Remarks: Day indicated that he examined

five specimens of this species, the longest of which was "5 inches" (127 mm). The two specimens clearly represent different species of *Glyptothorax*.

Esomus (Nuria) maderaspatensis Day, 1867a: 300. Type locality: Bowany River and Madras. POSSIBLE SYNTYPE: AMS B.7831 (1, 48 mm) **Madras** [but see below]. Remarks: Subsequent to the description of this species, Day (1875–78) placed the name in the synonymy of *Nuria danrica* (Hamilton). Specimens identified as *Nuria danrica* from Madras, Pegu, and Malabar were included in the specimens received at AMS. The locality recorded for this specimen in the register indicates that it was from Malabar and, therefore, a likely syntype of *Esomus (Nuria) maderaspatensis*. However, two original labels were found with the specimen in the jar: one indicating Madras as the locality of the specimen; the second indicating Pegu. Therefore, the type status of this species is uncertain.

Gobius madraspatensis Day, 1868c: 152. Type locality: Backwaters in Madras. POSSIBLE SYNTYPE: AMS B.8090 (1, 51 mm) **Madras**. Remarks: Day indicated that he examined three specimens, from "2‰ to 3 inches" (73.7 to 76.2 mm) in total length. Whitehead & Talwar (1976) report at least 10 other specimens, from ZSI and BMNH that, must be considered as possible type specimens.

Hara malabarica Day, 1865c: 184, pl. 13, fig. 3. Type locality: Mountain streams of Malabar, India. NON-TYPE: AMS B.7624 (1) South Canara. Remarks: This specimen was received at AMS as *Macrones malabaricus*, following the nomenclature in Day (1875–78). In the 1884 Annual Report, the specimen was indicated to be a type specimen, but Day apparently did not have any fish collections from South Canara until after 1867 (Day, 1870f). Therefore, this specimen cannot be considered as a type.

Carcharias malabaricus Day, 1873c: 529. Type locality: Palliport near Cochin, and Calicut on Malabar coast. SYNTYPE: AMS I.61 (1, 430 mm TL) Calicut. Remarks: Day indicated that he examined three specimens of this species, two of which were from Calicut. The Calicut specimens were said to be "16 inches" (406.4 mm) in length, which is about one inch (25.4 mm) smaller than the length of the specimen at AMS. This specimen was identified as *Carcharhinus dussumieri* (Müller & Henle, 1839) by Garrick (1982: 54).

Esomus malabaricus Day, 1867a: 299. Type locality: Trichoor in Malabar. POSSIBLE SYNTYPE: AMS B.7833 (1, 76.2 mm) Malabar. Remarks: Subsequent to the description of this species, Day (1875–78) placed the name in the synonymy of *Nuria danrica* (Hamilton). The specimens arrived at AMS identified as *N. danrica*, from a locality consistent with the type locality of *Esomus malabaricus*. Day indicated that he examined specimens "up to 3 inches" (76.2 mm) in total length. The AMS specimen is approximately 3 inches (76.2 mm) in standard length and, therefore, probably too large to be one of the examined specimens.

Spratelloides malabaricus Day, 1873b: 240. Type locality: Sea, ascending rivers in Malabar. PARALECTOTYPE: AMS B.8288 (1, 44 mm) Malabar. Remarks: Day indicated that he examined specimens of this species up to "3 inches" (76.2 mm) in length. Talwar & Whitehead (1971: 63) stated that the specimens examined by Day represented two species. They selected a ZSI specimen as lectotype, which they considered to represent a valid species in their new genus *Dayella*. The AMS specimen was of the second species, *Ehirava fluviatilis* (Deraniyagala).

Gobius masoni Day, 1873a: 107. Type locality: Bombay. SYNTYPE: AMS B.8089 (1, 75 mm) Bombay.

Barbus mclellandi Day, 1870d: 619. Type locality: Pegu and Moulmein. SYNTYPES: AMS B.7741 (1), B.7742 (1), and B.7743 (1), each from Moulmein. Remarks: This name was preoccupied when Day treated *Cyprinus mclellandi* Valenciennes (in Cuvier & Valenciennes, 1842) as a species of Barbus. Day (1871b) proposed *Barbus (Puntius) stoliczkanus* as a replacement. Three specimens identified as *Barbus stoliczkanus*, from the type locality of *B. mclellandi*, were included in the Day collection. An additional specimen identified as this species, AMS B.7542 (1) from Darjeeling, is not from the type locality and must, therefore, not be considered part of the type series. The species name was originally spelled mclellandi but changed to be consistent with Eschmeyer (1998).

Labeo melanampyx Day, 1865b: 298. Type locality: Mundikyum. NON-TYPE: AMS B.7556 (1, 21 mm) **Wynaad**. Remarks: This specimen was received at AMS identified as *Barbus melanampyx*, following the nomenclature in Day (1875–78). However, the locality associated with the specimen is not the same as the stated type locality. Day (1867b) noted that he obtained specimens of this species from the Wynaad two years after the name *Labeo melanampyx* was published. Thus, this specimen is not part of the type series.

Gobius melanosticta Day, 1876a: 290, pl. 63, fig. 2. Type locality: Backwaters of Madras. SYNTYPE: AMS B.8202 (1, 31 mm) **Madras**.

Atherina melanostigma Day, 1876a: 345. Type locality: Madras. SYNTYPE: AMS B.8357 (1, 58 mm) Madras. Remarks: Day reported specimens up to "3 inches" (76.2 mm) in length. This specimen was listed as a type in the AMS records, but was overlooked by Whitehead & Talwar (1976).

Pseudosynanceia melanostigma Day, 1875: 163 (figured in Day [1876a] on pl. 55, fig. 6). Type locality: Kurrachee, in Sind. QUESTIONABLE TYPE: AMS B.8183 (1, 118 mm) Kurrachee (Karáchi in annual report). Remarks: In the description of this species, Day stated that he obtained only one specimen (length 7 inches, 177.8 mm). The AMS specimen is approximately 6¼ inches (156 mm) in total length, and it bears a reasonable resemblance to the figure. However, there is also a specimen identified as this species at ZSI which has been regarded as the holotype (e.g., Eschmeyer 1998).

Ophichthys microcephalus Day, 1878: 665, pl. 170, fig. 2. Type locality: Malabar. SYNTYPE: AMS B.7843 (1, 634 mm) Madras. Remarks: Day stated that he examined three specimens of this species, each at least "25 inches" (635 mm) in length.

Labeo microphthalmus Day, 1877c: 542, pl. 132, fig. 4. Type locality: Himalayas from Punjab, Murree, Kangra, also Cashmere. SYNTYPE: AMS B.7666 (1, 251 mm) Himalayas. Remarks: This specimen was not listed as a type in the 1884 Annual Report, but the identification and locality of the specimen indicate that it should be so considered.

Macrones microphthalmus Day, 1877c: 446, pl. 100, fig. 4. Type locality: Burma along the valley of the Irrawaddi. SYNTYPE: AMS B.7918 (1, 169 mm) **Burma**. Remarks: Day provided no information regarding the number of specimens he examined, or their sizes. The locality associated with this specimen is vague, but consistent with the stated type locality of the species.

Mayoa modesta Day, 1870b: 553. Type locality: Northern India. POSSIBLE SYNTYPE: AMS registration number unknown, Assam. Remarks: This specimen was received at AMS as *Discognathus modestus*, following the nomenclature in Day (1875–78). In the original description of the species, Day indicated that he examined two specimens from northern India in the Calcutta Museum. He later repeated that information (Day, 1875–78), suggesting that he did not examine any additional specimens. However, Whitehead & Talwar (1976) reported two specimens at ZSI, Calcutta (one of which was listed as missing) and two additional specimens from Day's collection in NMW, Vienna. In addition, the 1884 AMS annual report listed *Discognathus modestus* from Assam among the species received from Day. A search of the register, card file, and database has so far failed to turn up any record of this specimen. If found, that specimen may be the missing ZSI

specimen, or another specimen of that species first examined by Day after publication of his *Fishes of India*.

Glyptosternum modestum Day, 1872d: 714. Type locality: Upper portion of Jumna [River]. SYNTYPES: AMS B.7562 (1, 64 mm) **Himalayas**, AMS B.7564 (1, 61 mm) **Simla**. Remarks: Subsequent to the description of this species, Day (1875–78) placed the name in the synonymy of *Glyptosternum pectinopterum* McClelland. One of the two specimens (AMS B.7564) arrived at AMS identified as *G. pectinopterum*. The other specimen (AMS B.7564) was identified as *G. modestum*, but that name was not shown in the packing list or annual report. The localities given for these specimens are consistent with the type locality of the species.

Barilius (Pachystomus) modestus Day, 1872a: 4. Type locality: Ravi River at Lahore. SYNTYPE AND NON-TYPE: AMS B.7884–85 (2, 73–100 mm) Punjab. Remarks: The Punjab is a region of western southern Asia that includes the city of Lahore. Therefore, the locality stated for the AMS specimen is consistent with the type locality of the species. However as Day indicated that he examined specimens up to "four inches" (101.6 mm) in length, this makes the larger of the two AMS specimens too large to be considered as a syntype.

Chatoessus modestus Day, 1870d: 622. Type locality: Bassein R., as high as Een-gay-gyee Lake [Burma]. PARALECTOTYPE: AMS B.7637 (1, 105 mm) **Burma**. Remarks: Day indicated that many specimens up to "5½ inches" (139.7 mm) were examined. Talwar & Whitehead (1971: 73) selected a ZSI specimen as lectotype and considered the species to be valid in *Gonialosa*. They claimed that the AMS specimen could not be a paralectotype, as they considered Day's description to be based on a single specimen. We find their reasoning flawed, for two reasons. Day clearly indicated that he examined more than one specimen, so his concept of the species was not based on a single individual. Also, by Talwar and Whitehead's reasoning, there should have been no need, and no justification, to select a specimen as lectotype if a single specimen (a holotype) was indicated.

Semiplotus modestus Day, 1870e: 101. Type locality: Hill ranges of Akyab. SYNTYPE: AMS B.7837 (1, 100 mm) Akyab. Remarks: Day indicated that he examined two specimens, of "4½ to 5½ inches in length" (114.3 to 139.7 mm). The size and locality information associated with this specimen is consistent with the information provided by Day. Whitehead & Talwar (1976) stated that a second specimen from Day's collection is at ZSI.

Nemacheilus multifasciatus Day, 1878: 617, pl. 153, fig. 7. Type locality: Darjeeling and Assam. SYNTYPE: AMS B.7737 (1, 59 mm) **Darjeeling**. Remarks: Day provided no information on the number or size range of the specimens he examined.

Barbus nashii Day, 1869a: 584. Type locality: Fraserpett River, at base of the Coorg Hills, Coorg District. NON-TYPE: AMS B.7693 (1, 183 mm) Canara. Remarks: This specimen was sent to AMS identified as *Scaphiodon nashii* (Day), but Day (1877c: 552) indicated that specimens from South Canara were not acquired by him until after publication of the name. Pethiyagoda & Kottelat (1994: 104) treated this specimen as a syntype and considered it to represent a valid species of *Osteochilichthys*.

Paradanio neilgherriensis Day, 1867a: 296. Type locality: Ootacamund Lake, Pykara, Avelanche and Kaity streams. SYNTYPES: AMS B.7724 (1), AMS B.7725 (1), both from Ootacamund. Remarks: These specimens were received at AMS as *Danio neilgherriensis*, following the nomenclature in Day (1875–78). The standard length of these specimens is 43.6 mm and 52.1 mm, however it is not possible to associate the registration numbers to either fish as the metal tags bearing these registration numbers are not attached to the fish, but are loose in the jar. Day indicated that he examined specimens up to "3½ inches" (88.9 mm) in total length, therefore we consider these specimens to be syntypes.

Barbus neilli Day, 1869a: 581. Type locality: (?) Kurnool. POSSIBLE SYNTYPE: AMS B.7870 (1, 84 mm) Deccan. Remarks: Day did not clearly state a type locality of this species. He reported that it was "very common at Kurnool", but, by our reading, the species was more wide ranging.

Gobius neilli Day, 1868c: 152. Type locality: Backwaters and along the sea-shore [India]. SYNTYPE: AMS B.8312 (1, 43 mm) **Madras**. Remarks: The account of this species does not include information on the provenance of the specimens examined. Most of the species described in the same publication were from Madras, and it is likely that this species was also collected there. The original label associated with this specimen lists Madras as the locality, as do the 1884 Annual Report and Day's packing list. Day reported that the specimens ranged in size from "1⅝₀ to 3⅜₀ inches" (38.1 to 81.3 mm), but did not indicate how many specimens were examined.

Labeo neilli Day, 1870e: 99. Type locality: Sittoung and Billing [rivers, Burma]. POSSIBLE SYNTYPE: AMS B.8150 (1, 105 mm) Burma. Remarks: This specimen was received at AMS as *Osteocheilus neilli*, following the nomenclature in Day (1875–78). The imprecise locality associated with the specimen is not inconsistent with that of the type locality of the species. However, Whitehead & Talwar (1976) indicate there are at least 14 possible syntypes for this species (not including the one mentioned herein), even though only 7 specimens were mentioned in the original description and the account in Day (1875–78). The AMS specimen is shorter than the maximum size (6 inches, 152.4 mm) of specimens examined by Day. Thus, the status of this specimen requires further investigation.

Callichrous nigrescens Day, 1870d: 616. Type locality: Throughout the branches of the Irrawaddi, in the Pegu and Sittoung rivers [Burma]. SYNTYPE: AMS B.7636 (1, 123) Burma. Remarks: Subsequent to the description of this species, Day (1875–78) placed this name into the synonymy of *Callichrous pabo*. This specimen was sent to AMS under that name. The locality associated with the specimen is vague, but not inconsistent with that of the type locality of the species. Day did not indicate how many specimens he examined, but stated that the largest specimen was "6½ inches" (165.1 mm), which is larger than the specimen sent to AMS.

Labeo nigrescens Day, 1870f: 371. Type locality: Mangalore. SYNTYPE: AMS B.7703 (1, 160 mm) Mangalore. Remarks: Day did not provide any information on the number of specimens examined or the size range of the specimens.

Caranx nigripinnis Day, 1876a: 225, pl. 51, fig. 5. Type locality: Madras and Andamans. SYNTYPE: AMS B.8043 (1, 147 mm) Madras.

Labeo nigripinnis Day, 1877c: 544, pl. 132, fig. 3. Type locality: Sind hills and rivers at their bases. SYNTYPE: AMS B.7842 (1, 88 mm) Sind.

Barilius nigrofasciatus Day, 1870d: 620. Type locality: Pegu and Moulmein. SYNTYPE: AMS B.7558 (1, not measurable) **Pegu**. Remarks: This specimen arrived at AMS identified as *Danio nigrofasciatus*, following the nomenclature in Day (1875–78). The specimen is badly dehydrated and broken into pieces.

Callichrous notatus Day, 1870d: 616. Type locality: Rivers of Burma. SYNTYPE AND NON-TYPE: AMS B.7982 (2, 93–128 mm) **Burma**. Remarks: Subsequent to the description of this species, Day (1875–78) placed this name into the synonymy of *Callichrous macrophthalmus* [sic, = *Callichrous macrophthalmos*] Blyth. These specimens were sent to AMS under that name. The locality associated with the specimens is vague, but no more so than the type locality of the species. Day did not indicate how many specimens he examined, but stated that the largest specimen was "4 inches" (101.6 mm). The larger of the two specimens at AMS is substantially longer than 4 inches and cannot, therefore, be considered a type.

Dentex (Synagris) notatus Day, 1871a: 684. Type locality: Andamans. POSSIBLE HOLOTYPE: AMS B.8219 (1, 187 mm) Andaman Is. Remarks: In the original description of the species, Day (1871a) stated that he had only one specimen of this species, but gave no indication of its size. The Zoological Survey of India lists one specimen in their catalogue (ZSI 229) which has been regarded as the holotype (e.g., Eschmeyer, 1998). However, because the AMS specimen is from the type locality, it must also be considered as the possible holotype.

Gobius ocellatus Day, 1873a: 107. Type locality: Bombay. SYNTYPE: AMS B.8055 (1, 107 mm) Bombay. Remarks: Day indicated that he examined specimens of this species up to "5½ inches" (139.7 mm) in length. This specimen was identified by Helen Larson in 1981 as *Aulopareia ocellatus*.

Pristipoma olivaceum Day, 1875: 73, pl. 19, fig. 1. Type locality: Coasts of Bealoochistan and Sind. SYNTYPE: AMS B.8335 (1, 187 mm) **Sind**. Remarks: Day provided no information on the number of specimens of this species he examined. He indicated that the species attained "at least a foot in length", which is larger than the AMS specimen.

Sciaena osseus Day, 1876a: 193, pl. 46, fig. 3. Type locality: Malabar coast of India. PARALECTOTYPE: AMS B.8249 (1) Malabar. Remarks: The account of this new species was written in such a manner that it is not clear whether Day examined more than one specimen. However, the specimen was sent to AMS identified as *Sciaena osseus*, and is therefore considered to be part of the type series. Talwar (1971) selected a ZSI specimen as lectotype, but did not comment on the AMS specimen.

Chela panjabensis Day, 1872a: 25. Type locality: Lahore, in the Ravi River. SYNTYPE: AMS B.7732 (1, 45 mm) **Lahore**.

Barilius (Barilius) papillatus Day, 1869b: 378. Type locality: Cossye River [Orissa], and the Mahanuddi. SYNTYPE AND NON-TYPE: AMS B.7909 (2, 56–92 mm) Orissa. Remarks: After Day described the species, he placed the name in the synonymy of *Barilius barna* (Hamilton). The locality given for the specimens is consistent with the type locality. However, Day (1869b) indicated that the species grew to "3 inches in length" (76.2 mm), which is substantially less than the length of the larger of the two specimens at AMS. Therefore, the smaller of the two specimens is considered a syntype, while the larger is not part of the type series.

Puntius parrah Day, 1865b: 301. Type locality: In rivers and inundated paddy-fields [Cochin, India]. SYNTYPE: AMS B.7840 (1, 70 mm) Kurriavanoor. Remarks: This specimen was received at AMS identified as *Barbus parrah*, following the nomenclature in Day (1875–78). Day indicted that he examined specimens ranging in size from "2⅝ to 5 inches" (71.1 to 127 mm). The locality listed for the specimen is a river in the vicinity of Cochin.

Gobius planiceps Day, 1876a: 296. Type locality: Madras. POSSIBLE SYNTYPE: AMS B.8286 (1, 33 mm) Madras. Remarks: Day indicated that he examined specimens up to "1½ inches" (38.1 mm) in length. If his measurements were recorded as total length, the AMS specimen would be too large to be considered a type, as it is nearly 1½ inches (38.1 mm) in standard length. We found the specimen dehydrated.

Nemacheilus pulchellus Day, 1873c: 528. Type locality: Bowany River. SYNTYPE: AMS B.7739 (1, 48 mm) **Madras**. Remarks: Day indicated that he examined 21 specimens of this species up to "2½ inches" (63.5 mm) in length. The Bowany River is near Madras.

Ailiichthys punctata Day, 1872d: 713. Type locality: Jumna at and below Delhi, also lower Punjaub rivers. SYNTYPE: AMS B.7570 (1, 69 mm) Delhi. Remarks: Day indicated that he examined specimens up to "4 inches" (101.6 mm) in length.

Nangra punctata Day, 1877c: 494, pl. 115, fig. 8. Type locality: Sone River at Bheer Bhoom. SYNTYPE: AMS B.7566 (1, 47 mm) Sone River. Remarks: Identified by Roberts & Ferraris (1998: 334) as *Gangra viridescens* (Hamilton, 1822).

Puntius punctatus Day, 1865b: 302. Type locality: no specific location given [Cochin, India]. POSSIBLE SYNTYPE: AMS B.7746 (1, 41 mm) **Kurriavanoor**. Remarks: This specimen was received at the AMS identified as *Barbus punctatus*, following the nomenclature in Day (1875–78). The locality listed for the specimen is a river in the vicinity of Cochin, the presumed type locality of the species. As Day reported that he examined specimens ranging in size from "2⅝ to 3⅘ inches" (63.5 to 86.4 mm), we consider this specimen to be a possible syntype.

Silurus punctatus Day, 1868c: 155. Type locality: Stream in Wynaad, about 3000 feet above sea level. SYNTYPE: AMS B.7990 (1, 131 mm) Wynaad. Remarks: *Silurus punctatus* Day was preoccupied by *Silurus punctatus* Cantor, 1842, and replaced by *Silurus wynaadensis* (Day, 1873b). The 1884 Annual Report listed *Silurus wynaadensis*, from the type locality, among the species received. Day indicated that he examined specimens ranging from "4 to 8⅕ inches" (101.6 to 205.7 mm) in total length, but not the number of specimens. This specimen must also be considered a syntype of *S. punctatus* Day.

Barbus (Puntius) punjaubensis Day, 1871b: 334. Type locality: Ravi R. at Lahore. NON-TYPE: AMS B.7545 (1, 20 mm) **Sind**. Remarks: The AMS specimen is from Sind, a region of Pakistan that does not include Lahore, the type locality of this species.

Serranus radiatus Day, 1868a: 699. Type locality: Near Madras, India. POSSIBLE HOLOTYPE: AMS B.8342 (1, 79 mm) **Madras**. Remarks: Subsequent to the description, Day (1875) placed the name in the synonymy of *Serranus morrhua* Valenciennes, 1833. The AMS specimen was sent identified as *Serranus morrhua* and the locality given for the specimen is the same as the type locality. The description of this species is written in a way that suggests that Day examined only one specimen of a total length of "4 inches" (101.6 mm). The size of the specimen is virtually the same (80 mm, vs. 79 mm), and identically marked, as the specimen illustrated in Day (1875, pl. 5, fig. 3), which was said to be drawn at full size and captured in 1867 at Madras. Thus, it is possible that the AMS specimen is the illustrated specimen and holotype of *Serranus radiatus*, even though a specimen at the Zoological Survey of India (ZSI 1676) was considered by Whitehead & Talwar (1976) to be the figured specimen.

Scomber reani Day, 1871a: 690. Type locality: Andamans. SYNTYPE: AMS B.8140 (1, 232 mm) Andamans. Remarks: Subsequent to the description of this species, Day (1875–78) placed the name in the synonymy of *Scomber microlepidotus* Rüppell. This specimen arrived at AMS identified as *S. microlepidotus*, from the type locality of *S. reani*. Day reported that he examined specimens up to "12 inches" (304.8 mm).

Nemacheilus semiarmatus Day, 1867a: 286. Type locality: Bowany and Seegoor rivers, Billicul Lake, and Ootacamund. SYNTYPE: AMS B.7740 (1, 47 mm) **Bowany**. Remarks: Day indicted that he examined specimens of this species up to "4 inches" (101.6 mm) in total length.

Nemacheilus serpentarius Day, 1870b: 551. Type locality: no locality stated. SYNTYPE: AMS registration number unknown. Remarks: Day proposed the name *Nemacheilus serpentarius* for three specimens he examined in the Calcutta Museum. At that time, he provided no indication of the provenance of the specimens. He later (Day, 1877c) placed that name into synonymy of *Homaloptera bilineata* Blyth and indicated that he had examined three specimens in the Calcutta Museum from the Tenasserim provinces. Whitehead & Talwar (1976) reported two specimens of *N. serpentarius* registered at ZSI, but not found during their inventory. The 1884 Annual Report lists *Homaloptera bilineata* from Tenasserim among the species received from Day, but no specimen so identified has yet been found at AMS. If found, that specimen should be considered a syntype of *Nemacheilus serpentarius*.

Arius serratus Day, 1877c: 462, pl. 105, fig. 3. Type locality: Sind. NON-TYPE: AMS B.7971 (1, 127 mm) Sind. Remarks: Day

stated that he examined only one specimen in his description of this species. The specimen deposited at AMS was listed as a type in the 1884 Annual Report and Register and was from the type locality. However, Whitehead & Talwar (1976) report that a specimen of this species from Day's collection is also registered at ZSI. In the description of the type specimen, Day did not include its size, but the illustration of the species was said to be full size, which would make the specimen approximately 95 mm SL, far smaller than the AMS specimen. Thus, it is unlikely that the AMS specimen is the holotype of the species. Kailola (1986) examined this specimen and also commented on the difficulty of assessing its type status. However, she identified the AMS specimen of *Arius serratus* as *Arius bilineatus*.

Cirrhina sindensis Day, 1872b: 319. Type locality: Sind Hills. SYNTYPE: AMS B.7661 (1, 158 mm) **Sind**. Remarks: This specimen arrived at AMS identified as *Labeo sindensis*, following the nomenclature in Day (1875–78). Day indicated that the specimens he examined ranged to "8 inches" (203.2 mm) in length.

Clupea sindensis Day, 1878: 638, pl. 163, fig. 2. Type locality: Seas of the Seychelles, Sind and Bombay. PARALECTOTYPE: AMS B.7642 (1, 113 mm) **Bombay**. Remarks: Talwar & Whitehead (1971) treated this name as valid in *Sardinella* and selected a lectotype from a specimen at ZSI. They considered the AMS specimen a paralectotype and conspecific with the lectotype.

Glyphidodon sindensis Day, 1873d: cclxiii. Type locality: Kurrachi. SYNTYPE: AMS I.144 (1, 45 mm) Sind. Remarks: Day indicated that he examined specimens of this species up to "4½ inches" (114.3 mm) in length. The locality stated for this specimen is an old spelling of Karachi, which is located within the region of Pakistan called Sind.

Chela sladoni Day, 1870d: 622. Type locality: Irrawaddi, as high as Mandalay [Burma]. SYNTYPE: AMS B.7852 (1, 86 mm) Prome. Remarks: Prome is a city on the Irrawaddy River, between the mouth of the river and Mandalay. Day indicated that the species was common, but he did not specify the lengths of the specimens examined.

Danio spinosus Day, 1870d: 621. Type locality: Pegu [Burma]. SYNTYPE: AMS B.7503 (1, 68 mm) Burma. Remarks: Day stated that he examined four specimens, from 2½ to 4 inches (63.5 to 101.6 mm) in length. This specimen was on loan and could not be examined.

Blennius steindachneri Day, 1873a: 110. Type locality: Kurrachee. SYNTYPE: AMS B.8003 (1, 83 mm) Sind. Remarks: This specimen was not indicated as being a type specimen in the 1884 Annual Report, but is listed as a type in the AMS register. The locality given for the specimen is a region that includes the type locality for the species. Day indicated that he examined specimens of this species up to "4 inches" (101.6 mm) in length.

Danio stoliczkae Day, 1870d: 621. Type locality: Moulmein, in tanks and streams [Burma]. SYNTYPES: AMS B.7646 (1, 39 mm), B.7744 (1, 24 mm), Moulmein, Burma. Remarks: Subsequent to the description of *Danio stoliczkae*, Day (1875–78) placed the name in the synonymy of *D. albolineata*. The specimens deposited at AMS were listed in Day's packing list as "*Danio albolineata*. Blyth. Moulmein (Blyth Type). Burma." The locality of these specimens is that of the type locality of *Danio stoliczkae*, from where Day collected "upwards of 100" specimens. These specimens are likely to be part of the type series of that species. However, Day (1870b: 558) noted that he examined 6 specimens of *Muria* [sic *Nuria*] *albolineata* in the Calcutta Museum from Moulmein, which may represent the type series of Blyth's name. It is possible that one or both of the AMS specimens may have come from this lot, as suggested by the wording of Day's packing list. However, the specimens in the Calcutta Museum were said to have been presented to the museum by a Mr Atkinson and not Major Berdmore who, from the introductory remarks in Blyth's (1860) paper, was responsible for most of the specimens studied by Blyth. One further note: specimens catalogued as AMS B.7741–3 and AMS B.7542 were incorrectly listed as syntypes of this species in Eschmeyer (1998). The former are, instead, syntypes of *Barbus (Puntius) stoliczkanus* Day, and the latter is not from the type locality of that species and should therefore not be considered as a type of either *Danio albolineata* or *Danio stoliczkae*.

Exostoma stoliczkae Day, 1877b: 782. Type locality: Basgo, Sneema, and Leh or Ladak on the head-waters of the Indus. SYNTYPE: AMS I.122 (1, 126 mm) Indus. Remarks: Day indicated that he examined 17 specimens of this species ranging in length from 4 to 7 inches (101.6 to 177.8 mm).

Serranus stoliczkae Day, 1875: 11, pl. 1, fig. 3. Type locality: Coast of Sind, common at Aden. PARALECTOTYPE: AMS B.8157 (1, 157 mm) **Aden**. Remarks: Day indicated that this species attained a length of "at least 12 inches" (304.8 mm). See Eschmeyer (1998) for information on lectotype designation.

Barbus (Puntius) stoliczkanus Day, 1871b: 328. Type locality: Pegu, Moulmein [Burma]. SYNTYPES: AMS B.7741 (1), B.7742 (1), B.7743 (1), all from Moulmein. Remarks: This name was proposed as a replacement for *Barbus mclellandi* Day, 1870d, which is preoccupied in *Barbus* by *Cyprinus mclellandi* Valenciennes (1842). The type series of Day's *Barbus mclellandi* are also types of his replacement name.

Cyprinodon stoliczkanus Day, 1872c: 258. Type locality: Stream at the village Joorun, and also at Lodai, along the edge of the Rann [Kachh, India]. SYNTYPES: AMS B.7730–7731 (2, 31–33 mm) **Cutch**. Remarks: Subsequent to the description of this species, Day (1875–78) placed the name in the synonymy of *Cyprinodon dispar* (Rüppell). The specimens arrived at AMS identified as *C. dispar* with the locality listed as Cutch (apparently an alternate spelling of Kachh). Day indicated that he examined 28 specimens, up to "1.6 inches" (40.6 mm) in length.

Euctenogobius striatus Day, 1868d: 272, unnumbered fig. Type locality: Backwaters around Madras, Conjeveram, and near Arcot. SYNTYPE: AMS B.8146 (1) Malabar. Remarks: A specimen arrived at AMS as *Gobius striatus*, following nomenclature in Day (1875–78). Day indicated that he examined specimens ranging from "1 to 5 inches" (25.4 to 127 mm) in length. The specimen was not found at AMS during this study.

Nemacheilus striatus Day, 1867b: 347. Type locality: Wynaad, at 3000 feet. SYNTYPE: AMS B.7487 (1, 48 mm) Wynaad. Remarks: Day indicated that he examined specimens up to "2½ inches" (63.5 mm) in length. This specimen was found in a dehydrated condition during this study.

Silundia sykesii Day, 1876b: 569. Type locality: Deccan and Kurnool. SYNTYPE: AMS B.8084 (1, 147 mm) **Kurnool**. Remarks: Day indicated that he examined one specimen from Kurnool "nearly 9 inches" (228.6 mm) in length and two from an unspecified part of the Deccan "up to 6½ inches" (165.1 mm). The AMS specimen is too short to be the Kurnool specimen, but its length is about that of the larger of the specimens without precise locality. Whitehead & Talwar (1976) indicated that specimens from Day's collection were also deposited at ZSI and NMW, and that one or more of the specimens are said to be from the Kistna River.

Boleophthalmus tenuis Day, 1876a: 305, pl. 65, fig. 1. Type locality: Estuaries of Kurrachee. LECTOTYPE: AMS B.7618 (1, 121 mm) Sind. PROBABLE PARALECTOTYPE: AMS B.8037 (1, 126 mm) Sind. Remarks: Whitehead & Talwar (1976) listed AMS B.8037 as *Boleophthalmus tenuis*. The lectotype was designated in Murdy (1989: 53), who considered the species to be valid, but in the genus *Scartelaos*. AMS B.8037 was considered by Murdy to be conspecific with the lectotype. However, Day's original list of shipped specimens indicates that only one specimen was sent to AMS, and the AMS register

lists only one specimen of this species. The specimen labelled AMS B.8037 was originally entered in the register as *Gobioides tenuis*, another species described by Day (also from Sind). The specimen labelled AMS B.8037 is evidently not that species and it appears that Day unintentionally sent AMS a second specimen of *Boleophthalmus tenuis* as *Gobioides tenuis* (see account of that species for further details).

Gobioides tenuis Day, 1876a: 319, pl. 69, fig. 3. Type locality: Sind. NON-TYPE: AMS B.8037 (1, 126 mm) Sind. Remarks: Day's packing list, the 1884 Annual Report, and the register all indicate that a specimen of this species, from the type locality, was sent to AMS. There are no longer any original labels associated with AMS B.8037, and the register entry for this number was overwritten to read *Boleophthalmus tenuis*. The specimen labelled as AMS B.8037 was identified in Murdy (1989) as *Scartelaos tenuis* (Day), a name based on *Boleophthalmus tenuis* Day and not *Gobioides tenuis*. Day's (1876a) account of *Gobioides tenuis* was unclear as to whether more than a single specimen was examined, and one specimen from Day's collection was registered in the ZSI collection (ZSI 2071), but said to be lost (Whitehead & Talwar, 1976). It appears that Day accidentally sent a second specimen of *Boleophthalmus tenuis* to AMS as *Gobioides tenuis*.

Ambassis thomassi Day, 1870f: 369. Type locality: Calicut and Mangalore [Malabar Presidency]. SYNTYPE: AMS I.148 (1, 83 mm) Malabar. Remarks: The locality associated with the specimen is vague, but it encompasses a broad region that includes the type locality.

Barbus (Barbodes) thomassi Day, 1874: 707. Type locality: South Canara. SYNTYPE: AMS I.139 (1, 158 mm) Canara. NON-TYPES: AMS B.3061 (1, 720 mm, dry skin) and B.3062. One specimen, AMS I.139, was listed in the register with a precise locality that is consistent with the type locality of the species. The register entries for the remaining two specimens have very rudimentary notations and no indication that either specimen was a type. A gallery label prepared for AMS B.3061 states the locality of the specimen as "Southern Canara, Western India." However, Day indicated that he examined specimens up to "18 inches" (457.2 mm) in length, which is much less than the length of this specimen, thus excluding it from type status. The status of the remaining specimen (AMS B.3062) is moot, as the register indicates that the specimen was destroyed in 1936.

Scaphiodon thomassi Day, 1877c: 551, pl. 134, fig. 1. Type locality: South Canara. SYNTYPE: AMS B.7825 (1, 114 mm) Canara. This specimen was examined by Pethiyagoda & Kottelat (1994: 104) and considered to represent a valid species of *Osteochilichthys*.

Nemacheilus triangularis Day, 1865b: 295. Type locality: Hills at Mundikyum. QUESTIONABLE SYNTYPE: AMS B.7738 (1, 49 mm) **Travancore**. This specimen was listed as a type in the 1884 Annual Report. However, the locality associated with the specimen is in the southern part of what is now Kerala, south of the type locality, which is near the city of Cochin near the northern part of Kerala State. It is more likely that this specimen was acquired by Day subsequent to his description of *Nemacheilus triangularis*.

Chela untrahi Day, 1869b: 381. Type locality: Mahanuddi. NON-TYPE: AMS B.7901 (1, 132 mm) Mahanuddi. Remarks: Day indicated examining specimens up to "5 inches" (127 mm) in total length, which is smaller than the size of the AMS specimen. Two additional specimens from the Day collection, AMS B.7783 (1, 82 mm) **Madras** and AMS B.7784 (1, 118 mm) **Madras** are also not considered part of the type series.

Clupea variegata Day, 1870d: 623. Type locality: Irrawaddi and its branches [Burma]. PARALECTOTYPE: AMS B.7676 (1, 158 mm) **Bassein**. Remarks: Day indicated that he examined many specimens, up to "7 inches" (177.8 mm) in length. Talwar & Whitehead (1971) selected a ZSI specimen as lectotype and considered the species to be valid in *Gudusia*. They claimed that the AMS specimen could not be a paralectotype, as they considered Day's description to be based on a single specimen. As discussed in the account of *Chatoessus modestus*, we disagree with their reasoning, and treat the AMS specimen as a paralectotype.

Puntius vittatus Day, 1865b: 303. Type locality: no specific locality stated [Cochin, India]. NON-TYPE: AMS B.7554 (1, 34 mm) **Madras**. Remarks: Although this specimen was listed in Whitehead & Talwar (1976) as a possible type specimen, the locality associated with the specimen is not close to Cochin.

Barbus (Puntius) waageni Day, 1872b: 325. Type locality: Chua Saidar Shah, Salt Range [Pakistan]. SYNTYPE: AMS B.7632 (1, 39 mm) **Salt Range**. Remarks: Day indicated that he examined specimens up to "2½ inches" (63.5 mm) in length.

Scaphiodon watsoni Day, 1872b: 324. Type locality: Sind Hills. SYNTYPE: AMS B.7751 (1, 107 mm) **Sind**. Remarks: Day gave no indication of the number, or sizes, of the specimens examined.

Barbus (Barbodes) wynaadensis Day, 1873c: 528. Type locality: Vithry [Wynaad, India]. PARALECTOTYPE: AMS B.7989 (1, 140 mm) **Wynaad**. Remarks: Day indicated that he examined upwards of 40 specimens of this species, up to "8 inches" (203.2 mm) in length. See Eschmeyer (1998) for information on lectotype designation.

Silurus wynaadensis Day, 1873b: 237. Type locality: Stream in Wynaad, about 3000 feet above sea level. SYNTYPE: AMS B.7990 (1, 131 mm) Wynaad. Remarks: *Silurus wynaadensis* was proposed as a replacement name for *Silurus punctatus* Day, 1868c, (which is preoccupied by *Silurus punctatus* Cantor, 1842) and, therefore, takes the same specimen as type.

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References

Anderson, J., [1879]. *Anatomical and zoological researches: comprising an account of the zoological results of the two expeditions to western Yunnan in 1868 and 1875; and a monograph of the two cetacean genera,* Platanista *and* Orcella. London: Bernard Quaritch. [Publication date corrected from 1878 in published corrigenda.]

Anon., 1885. Australian Museum (Report of the Trustees for 1884). Government Printer, Sydney. Pp. 46.

Anon., 1886. Australian Museum (Report of the Trustees for 1885). Government Printer, Sydney. Pp. 47.

Bleeker, P., 1849. Bijdrage tot de kennis der Blennioïden en Gobioïden van der Soenda-Molukschen Archipel, met beschrijving van 42 nieuwe soorten. Verh. Batav. Genootsch. Kunst. Wet. v. 22: 1–40.

Bleeker, P., 1875. Atlas ichthyologique des Indes Orientales Neerlandaises, publie' sous les auspices du Gouvernement colonial neerlandais. Tome VIII (Percoides II, (Spariformes),

Bogodoides, Cirrhiteoides). Pp. 156, pls. 321–354, 261–362.
Blyth, E., 1860. Report on some fishes received chiefly from the Sitang River and its tributary streams, Tenasserim Provinces. *Journal of the Asiatic Society of Bengal* 29(2): 138–174.
Cressey, R., 1981. Revision of Indo-west Pacific lizardfishes of the genus *Synodus* (Pisces: Synodontidae). *Smithsonian Contributions to Zoology* 342: 1–53.
Cuvier, G., & A. Valenciennes, 1842 (August). Histoire naturelle des poissons. Tome seizième. Livre dix-huitième. Les Cyprinoïdes. v. 16: i–xx + 1–472, pls. 456–487. [Valenciennes authored volume. i–xviii + 1–363 in Strasbourg edition.]
Cuvier, G., & A. Valenciennes, 1844 (July). Histoire naturelle des poissons. Tome dix-septième. Suite du livre dix-huitième. Cyprinoïdes. V. 17: i–xxiii + 1–497 + 2 pp., pls. 487–519. [Valenciennes authored volume. i–xx + 1–370 in Strasbourg edition.]
Day, F., 1865a. On the fishes of Cochin, on the Malabar coast of India. Part I. Acanthopterygii. *Proceedings of the Zoological Society of London* 1865(1): 2–40.
Day, F., 1865b. On the fishes of Cochin, on the Malabar Coast of India. Part II. Anacanthini. *Proceedings of the Zoological Society of London* 1865(1): 286–318.
Day, F., 1865c. *The fishes of Malabar*. Bernard Quaritch, London. Pp. i–xxxii + 1–293, pls. 20.
Day, F., 1867a. On the fishes of the Neilgherry Hills and rivers around their bases. *Proceedings of the Zoological Society of London* 1867(2): 281–302.
Day, F., 1867b. On some fishes from the Wynaad. *Proceedings of the Zoological Society of London* 1867(2): 347–350.
Day, F., 1868a. On some new or imperfectly known fishes of India. *Proceedings of the Zoological Society of London* 1867(3): 699–707.
Day, F., 1868b. On some new or imperfectly known fishes of India. *Proceedings of the Zoological Society of London* 1867(3): 935–942.
Day, F., 1868c. On some new or imperfectly known fishes of India. *Proceedings of the Zoological Society of London* 1868(1): 149–156.
Day, F., 1868d. On a new gobioid fish from Madras. *Proceedings of the Zoological Society of London* 1868(2): 272–273.
Day, F., 1869a. Observations on Indian fishes. *Proceedings of the Zoological Society of London* 1868(3): 580–585.
Day, F., 1869b. On the fishes of Orissa—Part II. *Proceedings of the Zoological Society of London* 1869(2): 369–387.
Day, F., 1870a. Remarks on some of the fishes in the Calcutta Museum—Part I. *Proceedings of the Zoological Society of London* 1869(3): 511–527.
Day, F., 1870b. Remarks on some fishes in the Calcutta Museum—Part II. *Proceedings of the Zoological Society of London* 1869(3): 548–560.
Day, F., 1870c. On some of the fishes in the Calcutta Museum—Part III. *Proceedings of the Zoological Society of London* 1869(3): 611–614.
Day, F., 1870d. On the freshwater fishes of Burma—Part I. *Proceedings of the Zoological Society of London* 1869(3): 614–623.
Day, F., 1870e. On the freshwater fishes of Burmah—Part II. *Proceedings of the Zoological Society of London* 1870(1): 99–101.
Day, F., 1870f. Notes on some fishes from the western coast of India. *Proceedings of the Zoological Society of London* 1870(2): 369–374.
Day, F., 1871a. On the fishes of the Andaman Islands. *Proceedings of the Zoological Society of London* 1870(3): 677–705.
Day, F., 1871b. Monograph of Indian Cyprinidae. Part II. *Journal of the Asiatic Society of Bengal* 40(2): 277–367.
Day, F., 1872a. Monograph of Indian Cyprinidae. Part IV. *Journal of the Asiatic Society of Bengal* 41(2): 1–29.
Day, F., 1872b. Monograph of Indian Cyprinidae. Part VI. *Journal of the Asiatic Society of Bengal* 41(2): 318–326, pl. 1.
Day, F., 1872c. Notes on fish, collected by Dr. Stoliczka in Kachh. *Journal of the Asiatic Society of Bengal* 41(2): 258–260.
Day, F., 1872d. On the freshwater siluroids of India and Burmah. *Proceedings of the Zoological Society of London* 1871(3): 703–721.
Day, F., 1873a. On some new or imperfectly known fishes of India and Burma. *Proceedings of the Zoological Society of London* 1873(1): 107–112.
Day, F., 1873b. On new or imperfectly known fishes of India. *Proceedings of the Zoological Society of London* 1873(1): 236–240.
Day, F., 1873c. On some new fishes of India. *Journal of the Linnean Society of London, Zoology* 11: 524–530.
Day, F., 1873d. Sea-fishes of India and Burma. In *Report on the sea fish and fisheries of India and Burma*, pp. cliii–cccxxxii. Calcutta.
Day, F., 1874. On some new or little-known fishes of India. *Proceedings of the Zoological Society of London* 1873(3): 704–710.
Day, F., 1875. *The fishes of India; being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma, and Ceylon*. Part 1: 1–168, pls. 1–40. London: Bernard Quaritch.
Day, F., 1875–78. *The fishes of India; being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma, and Ceylon*. London: Bernard Quaritch. Pp. 779, pls. 195.
Day, F., 1876a. *The fishes of India; being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma, and Ceylon*. Part 2: 169–368, pls. 41–78. London: Bernard Quaritch.
Day, F., 1876b. On some of the fishes of the Deccan. *Journal of the Linnean Society of London* 12(no. 64): 565–578.
Day, F., 1877a. Geographical distribution of Indian freshwater fishes—Part I. The Acanthopterygii, spiny-rayed, Teleostean fishes. *Journal of the Linnean Society of London* 13(67): 138–154.
Day, F., 1877b. On the fishes of Yarkand. *Proceedings of the Zoological Society of London* 1876(4): 781–807.
Day, F., 1877c. *The fishes of India; being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma, and Ceylon*. Part 3: 369–552, pls. 79–138. London: Bernard Quaritch.
Day, F., 1878. *The fishes of India; being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma, and Ceylon*. Part 4: i–xx + 553–779, pls. 139–195. London: Bernard Quaritch.
Day, F., 1883. Catalogue of the exhibits in the Indian Section. In *Great International Fisheries Exhibition, London, 1883*, anonymous editor, pp. 198. London: G. Norman & Sons.
Day, F., 1888a. Observations on the fishes of India—Part I. *Proceedings of the Zoological Society of London* 1888(3): 258–265.
Day, F., 1888b. *The fishes of India; being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma, and Ceylon*. Supplement: 779–816. London: Bernard Quaritch.
Day, F., 1889a. Fishes. In *The fauna of British India, including Ceylon and Burma*, ed. W.T. Blanford, vol. 1, pp. xviii + 548. London: Taylor and Francis; Calcutta: Thacker, Spink & Co.; Bombay: Thacker & Co.; and Berlin: R. Friedländer & Sohn.
Day, F., 1889b. Fishes. In *The fauna of British India, including Ceylon and Burma*, ed. W.T. Blanford, vol. 2, pp. xiv + 509. London: Taylor and Francis; Calcutta: Thacker, Spink & Co.; Bombay: Thacker & Co.; and Berlin: R. Friedländer & Sohn.
Eschmeyer, W.N. (ed.), 1998. *Catalog of Fishes*. San Francisco: California Academy of Sciences. Pp. 2905.
Garrick, J.A.F., 1982. Sharks of the genus *Carcharhinus*. *National Oceanic and Atmospheric Administration Technical Report,*

National Marine Fisheries Service Circular 445: i–vii, 1–194.

Gon, O., [1997]. Revision of the cardinalfish subgenus *Jaydia* (Perciformes, Apogonidae, *Apogon*). *Transactions of the Royal Society of South Africa* 51: 147–194. [Publication date corrected from 1996, on information provided by M.E. Anderson (pers. comm.)]

Kailola, P.J., 1986. Ariid systematics: comparison of the giant sea catfishes *Arius thalassinus* and *A. bilineatus* of the Indo-Pacific. In *Indo-Pacific Biology: Proceedings of the Second International Conference on Indo-Pacific Fishes*, eds. T. Uyeno, R. Arai, T. Taniuchi and K. Matsuura, pp. 540–549. Tokyo: Ichthyological Society of Japan.

Müller, J., & F.G.J. Henle, 1838–41. Systematische Beschreibung der Plagiostomen. Berlin. i–xxii + 1–200, 60 pls. [Pp. 1–28 published in 1838, reset pp. 27–28, 29–102 in 1839, i–xxii + 103–200 in 1841.]

Murdy, E.O., 1989. A taxonomic revision and cladistic analysis of the oxydercine gobies (Gobiidae: Oxyderciniae). *Records of the Australian Museum, Supplement* 11: 1–93.

Nelson, J.S., 1994. *Fishes of the World*, third edition. New York, etc., John Wiley & Sons, Inc. Pp. 600.

Paxton, J.R., & M.A. McGrouther, 1996. A history of the fish collection at the Australian Museum (1860–1968), with a summary of current Australian fish collections. In *Collection Building in Ichthyology and Herpetology*, eds. T.W. Pietsch and W.D. Anderson Jr., pp. 183–205. American Society of Ichthyologists and Herpetologists, Special Publication Number 3.

Pethiyagoda, R., & M. Kottelat, 1994. Three new species of the genera *Osteocheilichthys* (Cyprinidae), *Travancoria* (Balitoridae) and *Horabagrus* (Bagridae) from the Chalakudy River, Kerala, India. *Journal of South Asian Natural History* 1(1): 97–116.

Randall, J.E., & P.C. Heemstra, 1991. Revision of Indo-Pacific groupers (Perciformes: Serranidae: Epinephelinae), with descriptions of five new species. *Indo-Pacific Fishes* 20: 1–332.

Roberts, T.R., 1994. Systematic revision of Asian bagrid catfishes of the genus Mystus senus stricto, with a new species from Thailand and Cambodia. *Ichthyological Explorations of Freshwaters* 5(3): 241–256.

Roberts, T.R., & C.J. Ferraris Jr., 1998. Review of South Asian sisorid catfish genera *Gagata* and *Nangra*, with descriptions of a new genus and five new species. *Proceedings of the California Academy of Sciences* 50(14): 315–345.

Springer, V.G., & J.T. Williams, 1994. The Indo-west Pacific blenniid fish genus *Istiblennius* reappraised: a revision of *Istiblennius, Blenniella*, and *Paralticus*, new genus. *Smithsonian Contributions to Zoology* 565: 1–193.

Talwar, P.K., 1971. The generic relationship and identity of *Sciaena osseus* Day, 1876 (Pisces: Sciaenidae). *Journal of the Marine Biological Association of India* 11: 324–328.

Talwar, P.K., & P.J.P. Whitehead, 1971. The clupeoid fishes described by Francis Day. *Bulletin of the British Museum (Natural History), Zoology* 22(2): 59–85, pls. 1–2.

Temminck, C.J., & H. Schlegel, 1843 (11 February) Pisces. In: Fauna Japonica, sive descriptio animalium quae in itinere per Japoniam suscepto annis 1823–30 collegit, notis observationibus et adumbrationibus illustravit P.F. de Siebold. Parts 2–4: 21–72.

Thomson, J.M., 1997. The Mugilidae of the World. *Memoirs of the Queensland Museum* 41(3): 457–562.

Whitehead, P.J.P., & P.K. Talwar, 1976. Francis Day (1829–1889) and his collections of Indian fishes. *Bulletin of the British Museum (Natural History)*, Historical Series 5(1): 1–189, pls. 1–4.

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Appendix

Nominal species names proposed by Francis Day that are represented by specimens at the Australian Museum, sorted by current family. Sequence of family names follows Nelson (1994).

Carcharinidae
- *Carcharias malabaricus*

Ophichthyidae
- *Ophichthys microcephalus*

Clupeidae
- *Chatoessus modestus*
- *Clupea sindensis*
- *Clupea variegata*
- *Spratelloides malabaricus*

Cyprinidae
- *Barbus ambassis*
- *Barbus arenatus*
- *Barbus bovianicus*
- *Barbus burmanicus*
- *Barbus (Barbodes) dobsoni*
- *Barbus dukai*
- *Barbus guentheri*
- *Barbus (Barbodes) himalayanus*
- *Barbus (Barbodes) jerdoni*
- *Barbus (Barbodes) lithopidos*
- *Barbus mclellandi*
- *Barbus nashii*
- *Barbus neilli*
- *Barbus (Puntius) punjaubensis*
- *Barbus (Puntius) stoliczkanus*
- *Barbus (Barbodes) thomassi*
- *Barbus (Puntius) waageni*
- *Barbus (Barbodes) wynaadensis*
- *Barilius bakeri*
- *Barilius (Pachystomus) bleekeri*
- *Barilius evezardi*
- *Barilius interrupta*
- *Barilius (Pachystomus) modestus*
- *Barilius nigrofasciatus*
- *Barilius (Barilius) papillatus*
- *Brachygramma jerdonii*
- *Chela argentea*
- *Chela boopis*
- *Chela panjabensis*
- *Chela sladoni*
- *Chela untrahi*
- *Cirrhina sindensis*
- *Dangila burmanica*
- *Danio spinosus*
- *Danio stoliczkae*
- *Esomus (Nuria) maderaspatensis*
- *Esomus malabaricus*
- *Garra jerdoni*
- *Labeo denisonii*
- *Labeo melanampyx*
- *Labeo microphthalmus*
- *Labeo neilli*
- *Labeo nigrescens*
- *Labeo nigripinnis*
- *Mayoa modesta*
- *Opsarius guttatus*
- *Paradanio neilgherriensis*
- *Perilampus aurolineatus*
- *Puntius (Barbodes) dubius*
- *Puntius parrah*
- *Puntius punctatus*
- *Puntius vittatus*
- *Rohtee bakeri*
- *Scaphiodon irregularis*
- *Scaphiodon thomassi*
- *Scaphiodon watsoni*
- *Semiplotus brevidorsalis*
- *Semiplotus modestus*

Balitoridae
- *Nemacheilus chryseus*
- *Nemacheilus denisoni*
- *Nemacheilus multifasciatus*
- *Nemacheilus pulchellus*
- *Nemacheilus semiarmatus*
- *Nemacheilus serpentarius*
- *Nemacheilus striatus*
- *Nemacheilus triangularis*

Bagridae
- *Hara malabarica*
- *Macrones armatus*
- *Macrones bleekeri*
- *Macrones microphthalmus*
- *Olyra burmanica*
- *Pseudobagrus chryseus*

Siluridae
- *Callichrous egertonii*
- *Callichrous nigrescens*
- *Callichrous notatus*
- *Silurus dukai*
- *Silurus punctatus*
- *Silurus wynaadensis*

Schilbidae
- *Ailiichthys punctata*
- *Pseudeutropius acutirostris*
- *Silundia sykesii*

Sisoridae
- *Euglyptosternum lineatum*
- *Exostoma andersonii*
- *Exostoma stoliczkae*
- *Glyptosternum madraspatanum*
- *Glyptosternum modestum*
- *Nangra buchanani*
- *Nangra punctata*

Clariidae
- *Clarias assamensis*

Ariidae
- *Arius acutirostris*
- *Arius andamanensis*
- *Arius burmanicus*
- *Arius serratus*

Synodontidae
- *Saurus indicus*

Mugilidae
- *Mugil hamiltonii*
- *Mugil jerdoni*
- *Mugil klunzingeri*

Atherinidae
- *Atherina melanostigma*

Aplocheilidae
- *Panchax argenteus*

Cyprinodontidae
- *Cyprinodon stoliczkanus*

Mastacembelidae
- *Mastacembelus guentheri*

Scorpaenidae
- *Pseudosynanceia melanostigma*
- *Scorpaena bleekeri*

Ambassidae
- *Ambassis thomassi*

Serranidae
- *Serranus coromandelicus*
- *Serranus radiatus*
- *Serranus stoliczkae*

Apogonidae
- *Apogon ellioti*

Carangidae
- *Caranx bidii*
- *Caranx nigripinnis*

Lutjanidae
- *Genyoroge grammica*

Haemulidae
- *Pristipoma olivaceum*

Sparidae
- *Chrysophrys cuvieri*
- *Crenidens indicus*

Nemipteridae
- *Dentex (Synagris) notatus*

Sciaenidae
- *Otolithus brunneus*
- *Sciaena glaucus*
- *Sciaena osseus*

Mullidae
- *Upeneoides fasciolatus*
- *Upeneoides guttatus*

Cichlidae
- *Etroplus canarensis*

Pomacentridae
- *Glyphidodon leucopleura*
- *Glyphidodon sindensis*
- *Pomacentrus labiatus*

Blenniidae
- *Blennius steindachneri*
- *Petroscirtes lienardi*
- *Salarias alboguttatus*
- *Salarias andamensis*

Eleotridae
- *Eleotris canarensis*

Gobiidae
- *Amblyopus buchanani*
- *Apocryptes bleekeri*
- *Apocryptes cantoris*
- *Boleophthalmus glaucus*
- *Boleophthalmus tenuis*
- *Euctenogobius cristatus*
- *Euctenogobius striatus*
- *Gobioides tenuis*
- *Gobius andamanensis*
- *Gobius griseus*
- *Gobius madraspatensis*
- *Gobius masoni*
- *Gobius melanosticta*
- *Gobius neilli*
- *Gobius ocellatus*
- *Gobius planiceps*
- *Sicydium griseum*

Scombridae
- *Scomber reani*

Ariommatidae
- *Cubiceps indicus*

Belontiidae
- *Trichogaster labiosus*

Soleidae
- *Solea elongata*

Cynoglossidae
- *Cynoglossus buchanani*
- *Cynoglossus dispar*

Tetraodontidae
- *Tetrodon leopardus*

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The Glacidorbidae (Mollusca: Gastropoda: Heterobranchia) of Australia

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ABSTRACT. The heterobranch gastropod family Glacidorbidae (?Pulmonata) is known only from temperate Australia and Chile. The Australian taxa are reviewed and three new genera, *Benthodorbis, Striadorbis* and *Tasmodorbis* are described based on differences in their shells, especially the protoconchs, and in their opercula and radulae. Nineteen species of Australian glacidorbids are recognised, all but four of them new. Of the four Australian species previously included in *Glacidorbis*, only two, *G. hedleyi* (Iredale) from New South Wales and Victoria, and *G. occidentalis* Bunn & Stoddart from south Western Australia, are retained in that genus. Eleven new species of *Glacidorbis* are described, seven from Tasmania (*G. bicarinatus, G. catomus, G. atrophus, G. decoratus, G. costatus, G. tasmanicus* and *G. circulus*), one (*G. isolatus*) from New South Wales, two (*G. otwayensis* and *G. rusticus*) from Victoria and one (*G. troglodytes*) from South Australia. *Striadorbis* contains the Tasmanian *S. pedderi* (Smith), and two new species, *S. spiralis* from western Victoria and *S. janetae* from Tasmania. *Benthodorbis* contains two species, both from old lakes in Tasmania; *B. pawpela* (Smith) from Great Lake and *B. fultoni* from Lake Sorell. *Tasmodorbis* contains a single species found in western Tasmania, *T. punctatus*, unique in having internal shell pores. *Glacidorbis costatus* is known only from Pulbeena Swamp in NW Tasmania and appears to be recently extinct, possibly as a result of draining of the swamp in the early part of this century. A cladistic analysis with the South American member of the family, *Gondwanorbis*, as the outgroup, supports the monophyly of the genera recognised.

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Small-sized Australian freshwater molluscs have, in recent years, been shown to be much more diverse than previously imagined. Nearly all of this diversity is contained within the caenogastropod family Hydrobiidae (see Ponder, 1991 and Ponder & de Keyzer, 1998 for review), while other families of small-sized freshwater gastropods such as the Assimineidae, Bithyniidae, Planorbidae and Glacidorbidae are known to contain a several undescribed taxa. This paper revises the taxa included in the Glacidorbidae.

A tiny flat-spired gastropod, *Glacidorbis hedleyi*, was described by Iredale (1943) from Blue Lake, Mount Kosciuszko, NSW. Iredale included his new taxon in the basommatophoran pulmonate family Planorbidae but Meier-Brook & Smith (1976) showed that the genus was operculate and reviewed the known species. While they suggested similarities with the hydrobiids, they did not make any decision on the placement of the genus pending anatomical investigation and Smith (1979) placed

Glacidorbis "close to the Hydrobiidae" while Smith & Kershaw (1979, 1981) included it in the Hydrobiidae. Glacidorbidae was introduced by Ponder (1986) who described the anatomy of *G. hedleyi* and erected a new superfamily for the group that he considered to be atypical, probably paedomorphic, pulmonates. A pulmonate relationship was accepted by Visser (1988), although this author suggested that it had a basal position in the basommatophorans, rather than "the suggestion of Ponder (1986) that Glacidorbidae represent a neotenous group derived from the Lymnacea". In fact, Ponder (p. 77) argued that *Glacidorbis* may be derived from "proto-pulmonate" ancestors of the Amphibolacea-Ellobiacea, representing a freshwater incursion quite independent of the major lymnaeoidean radiation. In contrast to this view of the relationship of the family, Haszprunar (1988), Haszprunar & Huber (1990) and Huber (1993) argued that because of the lack of a typical pentaganglionate nervous system, a pneumostome, procerebrum and dorsal bodies, *Glacidorbis* was an "allogastropod", a grouping introduced by Haszprunar (1985) for the "lower heterobranchs" and equivalent to Heterostropha as used by Ponder & Warén (1988). Unpublished sperm ultrastructural data (J. Healy, pers. comm.) suggest relationships with basal pulmonates. The pulmonate placement of this group was provisionally followed by Stanisic (1998) in his review of the family for the "Fauna of Australia". The group was placed in a separate "order" (Glacidorbiformes) within the "subclass Sinistrobranchia" by Starobogatov (1988) but this classification has not been considered seriously by other workers. We consider a pulmonate relationship is still probable and that *Glacidorbis* is highly paedomorphic, a factor explaining the absence of many of the typical pulmonate characters (see also Ponder & Lindberg, 1997). This assessment could be readily tested using molecular data but is beyond the scope of this paper.

Only four species assigned to *Glacidorbis* have previously been described from Australia, two of these (*Valvata*(?) *pedderi* Smith, 1973; *Glacidorbis pawpela* Smith, 1979) from Tasmania, one from SW Australia (*G. occidentalis* Bunn & Stoddart, 1983) and *G. hedleyi* (Iredale, 1943) from the Great Dividing Range of Victoria and New South Wales. Smith & Kershaw (1981) mapped the distributions of the species of *Glacidorbis* known at that time and Ponder (1996) mapped *Glacidorbis* records in NE Tasmania noting that they comprised "two or three undescribed species".

A few studies have been made on the biology and ecology of these animals, other than basic habitat and brooding. Ponder (1986) described the reproduction and feeding of *Glacidorbis hedleyi*, Boulton & Smith (1985) described the ecological requirements of that species, and Bunn *et al.* (1989) described the ecology of *G. occidentalis* Bunn & Stoddard, 1983.

Material and methods

Material was collected by hand either by washing substrate (e.g., vegetation, roots, wood, rock, gravel) into a plastic bowl or small bucket or by using a hand sieve, with a mesh size of c. 1 mm, and sweeping the vegetation. The resulting sample was gently elutriated, the light material discarded. A few menthol crystals were added to the sample which was left to stand overnight in an attempt to relax at least some of the specimens. The sample was then bulk fixed in c. 10% neutralised formalin, later transferred to 5% buffered formalin. Specimens were sorted from the bulk sample using a dissecting microscope.

Material from the collections of various institutions was also utilised during the study (see list of abbreviations).

Although the radulae proved difficult to manipulate, they were mounted using standard methods. The buccal masses were dissolved using a strong solution of potassium hydroxide, the radulae were removed, washed in distilled water and air dried to glass cover slips which were then fixed to SEM stubs. Shells and opercula were mounted using standard methods. Most of the material was examined using a Cambridge 120 SEM, although some was examined using a LEO 435VP SEM (both with Robinson backscatter detector). Images were captured digitally.

A cladistic analysis was conducted using the data matrix given in Table 1 with PAUP*4b2 (Swofford, 1999) and the default heuristic search options and 100 random iterations. *Gondwanorbis* was defined as the outgroup. Bremer support was calculated using TreeRot ver. 2 (Sorenson, 1999).

Abbreviations

Shell measurements: aph—aperture height; apw—aperture width; dmax—maximum diameter; dmin—minimum diameter; mdht—height (at mid point of shell); mxht—maximum height of shell; whl—total number of whorls.

Collectors: ACM—Alison C. Miller; BJS—Brian. J. Smith; DLB—Des L. Beechey; FEH—Frank E. Hermans; GAC—Gerard A. Clark; IFCT—Inland Fisheries Commission, Tasmania; JH—Jane Hall; JHW—Janet H. Waterhouse; JMP—Julie M. Ponder; RdK—Roger de Keyzer; SAC—Stephanie A. Clark; WFP—Winston F. Ponder; WFPj—Warwick F. Ponder.

Institutions: AMS—Australian Museum, Sydney; MV—Museum of Victoria; QVM—Queen Victoria Museum, Launceston; SAM—South Australian Museum, Adelaide; TM—Tasmanian Museum, Hobart; WAM—Western Australian Museum.

Miscellaneous: AMG—Australian Map Grid, cond.—conductivity (in mS/cm at 12°C); NP—National Park; SF—State Forest.

Taxonomy

The following diagnosis of the monotypic superfamily and family are modified from Ponder (1986).

Glacidorboidea and Glacidorbidae Ponder, 1986

Diagnosis. Shell small to minute (most species less than 2 mm in maximum diameter, one species slightly less than 4 mm), dextrally coiled, orthostrophic to hyperstrophic, with flat or near flat spire to planispiral, with wide, shallow umbilicus. Operculum circular to oval, multispiral to

paucispiral, with central to eccentric nucleus. Jaw with dorsal and ventral elements. Radula with large central teeth bearing several sharp cusps on a pointed mesocone, with broader, arched base lacking additional cusps. Lateral teeth vestigial or narrow and small; marginal teeth absent. Head-foot (details only known for a few species of *Glacidorbis*) with long cephalic tentacles with eyes in middle of bases, foot posteriorly bifid, anteriorly with lateral processes; snout short and very broad. Pallial cavity (anatomical details only known for two species in two genera, *Glacidorbis* and *Striadorbis* n.gen., and superficially for a third genus—*Gondwanorbis*) widely open, not modified as a lung, with ciliated ridge on right side. Anus and female genital opening within pallial cavity. Stomach simple, intestine short and straight, anus opening about mid-way along pallial cavity. Pericardium at posterior end of pallial cavity. Nerve ring anterior to buccal bulb, visceral loop with slight chiastoneury and lacking distinct parietal ganglia ("triganglionate" condition). Protandrous, and brooding. Female system partly pallial, lacking separate bursa copulatrix, with several large embryos brooded in mantle cavity. Prostate gland separate from vas deferens, penis narrow and small, completely invaginated, with large sucker or knob-like glands in the large praeputium.

Remarks. *Glacidorbis* shares many anatomical characters with other heterobranchs (Ponder, 1986), as indicated by the following characters in particular: the kidney is in the mantle roof, the ctenidium is absent, the oesophagus is simple (lacking glands and dorsal folds), the snout is short and broad and fused to the dorsal part of the anterior foot, the eyes are in the middle of the tentacle bases, and the spermatozoa are spirally ridged. The ciliated mantle fold may be homologous with the ciliated ridges seen in many aquatic heterobranchs (Haszprunar, 1988). Dorsal and ventral jaw elements and the organisation of the reproductive system, particularly the penial apparatus, are characters that strongly suggest pulmonate relationships.

Three new genera of glacidorbids are described below. The monophyly of the four Australian genera is supported in a cladistic analysis (see Discussion for details). A key to the five genera now recognised in the family is given.

Key to genera

1 teleoconch growth lines orthocline 2–4

—— teleoconch growth lines prosocline ..... *Benthodorbis*

2 shell keeled mid dorsally (and sometimes) mid ventrally 3,4

—— shell evenly convex dorsally and ventrally 3,4

—— shell keeled in middle of periphery ..... *Gondwanorbis*

3 operculum paucispiral with subcentral to eccentric nucleus; with or without external pustules 5

—— operculum paucispiral with central nucleus; with external pustules ..... *Striadorbis*

—— operculum multispiral with central nucleus; without external pustules ..... *Tasmodorbis*

4 protoconch with pustules or pits over whole surface ..... *Glacidorbis*

—— protoconch with pustules on clearly demarcated initial portion followed by smooth portion ..... *Glacidorbis*

—— protoconch with pustules in early part, followed by well-spaced spiral threads ..... *Striadorbis*

—— protoconch of axial rugae crossed by numerous spiral cords with linear interspaces ..... *Tasmodorbis*

—— protoconch with fine spiral and axial threads over whole surface ..... *Benthodorbis*

5 operculum with external pustules ..... *Glacidorbis*

—— operculum lacking external pustules ..... *Benthodorbis*

Glacidorbis Iredale, 1943: 227

Type species. *Glacidorbis hedleyi* Iredale, 1943, by original designation.

Diagnosis. Shell orthostrophic, near planispiral. Protoconch terminated by abrupt change in sculpture, lacking varix; sculptured with pustules or pits over whole surface, or on initial portion only with remaining part smooth. Teleoconch whorls evenly convex or ridged or keeled near mid-dorsally and near mid ventrally, sculptured with orthocline axial growth lines or ridges, sometimes also with spiral sculpture. Operculum paucispiral, with subcentral to eccentric nucleus, and surface covered with minute pustules. Radula with equal-sized cusps on mesocone and major articulatory thickening on base at anterior edge of each tooth, or subequal with posterior articulation.

Glacidorbis hedleyi Iredale, 1943

Glacidorbis hedleyi Iredale, 1943: 227; Meier-Brook & Smith, 1976: 192, figs. 8–11; Boulton & Smith, 1985: 123–126, fig. 1; Smith, 1979: 123, fig. 2 (part); Smith & Kershaw, 1979: 40 (fig. in text); Ponder, 1986: 53–81, figs. 1–20, 22A; Smith, 1992: 223–224.

Type material. LECTOTYPE designated by Meier-Brook & Smith, 1976: 192; damaged and mounted on SEM stub, AMS C100597. PARALECTOTYPES: 40, AMS C22789.

Type locality. Blue Lake, Mount Kosciusko, NSW, 36°24'S 148°19'E, dredged from 35 ft (10.7 m), C. Hedley, 1906.

Additional material examined. NEW SOUTH WALES: stn C780N-A, Dawson Spring, Mt Kaputar, 30°17'S 150°9.5'E, on sedges, 10 m from spring source, 8 Nov 1983, P.H. Colman (many, AMS C140421); stn C780N-B, same loc., date & coll., 1343 m, in small rapids on sedges, 30 m from spring source (many, AMS C140423); stn C780N-C, same loc., date & coll., on plants and rocks in pool, c. 200 m from spring source (many, AMS C140426); same loc., date and coll., (1, AMS C362933); same loc., just above little dam opposite Ranger Headquarters, 1500 m, in sedges etc., 27 Nov 1991, SAC (14, AMS C351554); stn AM9, N of Dorrigo, Moonpar National Forest, off Mills Rd, Moonmerri Ck just above Nymboida River junction, 30°11.52'S 152°41.5'E, 415 m, under stones, 11 Mar 1981, WFP & O.L. Griffiths (2, AMS C128705); stn 5, tributary of Bobo Creek, NE of Dorrigo, 30°13'S 152°50'E, 500 m, rainforest and hoop pine, small flowing stream, 11 Mar 1981, WFP, J. Stanisic & O.L. Griffiths (3, AMS C361956); stn 16HV, Tombolla Creek at N end of Tuggolo Forest Way, 31°27'S 151°24.5'E, small stream, moss covered rocks, 23 Feb 1988, WFP & JMP (many, AMS C309358); stn 13HV, South Head Ck, on track 500 m SW from road between Snowball Rd and Nundle Forest Way, Nundle SF, 31°27.04'S 151°16.4'E, 1190 m, on moss and other weeds in clumps of saturated moss, 23 Feb 1988, WFP (several, AMS C306339); stn 10HVC(A), E of Nundle, Nundle SF, Ponderosa Forest Park, Four Mile Ck tributary, c. 200 m E of forestry camp, 31°28.05'S 151°15.46'E, 1240 m, small slow flowing clear stream, moss and liverworts on rocks, 23 Feb 1988, WFP (1, AMS C306338; 18, AMS C361945); stn 10HVB, same loc., pond with boulders and sand, 23 Feb 1988, WFP (20, AMS C361964); stn 10HVD, same loc., date & coll., spring with boulders and sand (many, AMS C361974); stn 12HV, Duncans Creek, Zircon Gully Picnic Area, Nundle SF, just off Nundle Forest Way, 31°28.14'S 151°14.18'E, 23 Feb 1988, WFP & JMP (many, AMS C309349); stn MN7, Norfolk Falls, Warung SF, Liverpool Range, 31°44'S 150°0'E, under rock in quiet side branch of creek above falls, 6 Nov 1985, JHW (1, AMS C303281); stn BT1385, swamp on Boggy Swamp Ck tributary, beside Pheasant Ck Rd, 2.5 km E of Thunderbolts Trail, Barrington Tops SF, 31°53.24'S 151°31.52'E, cutting grass beside road, 28 Mar 1985, WFP (many, AMS C354033, AMS C306342); stn BT1985, Paddys Ck, S Green Gap, on trail between Paddys Ck and Barrington Trails, Stewarts Brook SF, 31°55.66'S 151°26.04'E, in weed and seepage at edge, 28 Mar 1985, WFP (many, AMS C306336); stn BT002, Barrington Tops, Polblue Swamp, 31°57.4'S 151°25.41'E, in swamp, amongst moss and macrophytes, 20 Dec 1997, WFP (many, AMS C365715); stn BT2085, Polblue Swamp, Barrington Tops, 31°57.4'S 151°25.7'E, *Sphagnum*-sedge swamp, 28 Mar 1985, WFP (11, AMS C306335); stn MN31, small tributary of Cobcroft Creek, Werrikimbe NP, E of Walcha, 31°14'S 152°10'E, rainforest, under rocks in gravelly runs, 10 Nov 1985, I. Loch & JHW (5, AMS C361961); stn 24HV, Cobcroft Creek, at Cobcroft Rest Area, Werrikimbe NP, 31°14.833'S 152°10.667'E, rainforest, mossy stones and trickle, liverworts, 25 Feb 1988, WFP & JMP (several, AMS C309368); stn 25HV, swamp from top ridge, Fenwicks Rd, 2 km N from Fenwicks River Crossing, Doyles River SF, 31°18'S 152°1.417'E, swamp, 25 Feb 1988, WFP & JMP (many, AMS C309369); stn 19HV, spring c. 1.5 km from N entry to Riamukka SF, S side of Dennes Sugarloaf Trig., 31°18.25'S 151°48.617'E, duck weed and algae, 24 Feb 1988, WFP & JMP (2, AMS C309364); stn 22HV, small creek on Enfield Rd, Enfield SF, 1 km NW from camp, 31°19.45'S 151°51.933'E, 1060 m, on liverworts (dislodged and submerged), 24 Feb 1988, WFP (many, AMS C361958); stn 20HV, Nundle Creek just below picnic area, 31°20'S 151°51.967'E, in weed, 24 Feb 1988, WFP & JMP (many, AMS C309365); stn 18HV, at edge of Riamukka SF, to W of Brackendale Rd, N of Nowendoc, 31°21.883'S 151°41.417'E, small creek emerging from cutting grass swamp, 23 Feb 1988, WFP & JMP (several, AMS C309361); stn E96-13, NW of Nowendoc, Wild Cattle Ck at Millers Rd, 31°27.167'S 151°34.75'E, small swift stream in leaves etc. in Nowendoc SF, 8 Apr 1996, WFP (many, AMS C311580); stn E96-12, Watts Ck, Nowendoc SF, NW of Nowendoc, 31°29.5'S 151°37'E, in small side channel of swiftly flowing creek with mud and weed, 7 Apr 1996, WFP (several, AMS C311232); stn 17HV, tributary of Back Creek, Tuggolo SF, on Tuggolo Forest Way, 31°30.91'S 151°25.66'E, swampy edges, moss covered stones, 23 Feb 1988, WFP & JMP (6, AMS C309360); stn 1HV, Fern Tree Gully, N of Rylstone, 32°39.5'S 150°2.5'E, small boggy seepages, 21 Feb 1988, WFP & JMP (several, AMS C309321); stn BT2285, The Big Hole, Barrington River, Barrington Tops NP, 32°2.02'S 151°28.17'E, 1390 m, large pool, stream and seeps, 28 Mar 1985, WFP (several, AMS C306337); Gloucester River at Gloucester Tops Rd., 32°5.9'S 151°35.4'E, in swamp, 27 Mar 1985, WFP (many, AMS C306334); Burraga Swamp, Allyn Range, Barrington Tops NP, 32°6.7'S 151°25.6'E, in humus/peat and under logs, 20 Feb 1983, M. Shea & E. Cameron (10, AMS C137729); NW of Dungog, Barrington Tops NP, Allyn Range, Burraga Swamp, 32°6.7'S 151°25.6'E, in damp peat and moss beside log, Feb 1983, M. Shea (many, AMS C306332); Paterson River tributary, S of Burraga Swamp, SSW of Mt Lumeah, Barrington Tops NP, 32°6.9'S 151°25.5'E, 980 m, 11 Feb 1982, WFP (many, AMS C306331); Currys Springs, on Oberon Rd, c. 2 km from Kanangra Walls Rd, Kanangra Boyd Plateau, 33°50.1'S 149°58.2'E, on leaves etc., 11 Dec 1979, WFP & J. Stanisic (many, AMS C353950); Clarence, off Bells Line of Road, small boggy swamp, 33°29'S 151°14'E, swamp, 21 Jun 1990, GAC (8, AMS C361973); Terrace Ck, Jenden SF, 33°36.5'S 150°2'E, 21 Apr 1984, WFP (many, AMS C353942); Middle of Terrace Ck, N of Jenolan Caves, Blue Mountains NP, 33°46.5'S 150°0.2'E, small flowing creek and drain by road, 21 Apr 1984, WFP (many, AMS C351556); stn 25, Stockyard Ck, 150 m SE of Terrace Ck, tributary of Jenolan River, off 4WD track, N of Jenolan Caves, 33°46.6'S 150°0.3'E, in watercress and roots of willows, 13 Dec 1979, WFP (4, AMS C361965); stn RI-7, Imperial Cave Resurgence, Jenolan Caves, 33°49.2'S 150°1.8'E, 19 Apr 1993, S. Eberhard (1, AMS C361944); stn NSW487, eastern headwaters, Council Ck, near Kanangra-Boyd NP, 33°50.51'S 150°0.8'E, 1180 m, *Sphagnum* and gelatinous algae on gravelly substrate, 19 Nov 1992, G. Wilson & party (several, AMS C307132); stn NSW486, spring-fed bog near Luthers Ck, Kanangra-Boyd NP, 33°52.82'S 150°2.62'E, 1225 m, *Sphagnum* and gelatinous algae over silt, 11 Nov 1992, G. Wilson & party (several, AMS C307131); Boyd Plateau, spring into creek, 33°53'S 150°2.67'E, Oct 1988, WFP (many, AMS C361968); stn NSW485, Mumbedah Swamps, Kanangra-Boyd NP, 33°53.76'S 150°3.92'E, 1200 m, *Sphagnum* amongst clumps of sedge, 18 Nov 1992, G. Wilson & party (several, AMS C307129); stn NSW484, Belarah Swamp, Kanangra-Boyd NP, 33°54.31'S 150°4.65'E, 1185 m, *Sphagnum*, sticks and roots submerged in stream, 18 Nov 1992, G. Wilson & party (several, AMS C307127); stn NSW483, Oldmeadow Swamp, Box Ck tributary, off Kowmung River Fire Trail, Kanangra-Boyd NP, 33°56.5'S 150°2.6'E, 1245 m, *Sphagnum* and mixed water plants in spring-fed water, 18 Nov 1992, G. Wilson & party (several, AMS C307125); Small boggy creek, upper Little Morong Creek, Boyd Plateau, Blue Mountains, 33°56.5'S 150°3'E, 21 Apr 1984, WFP (many, AMS C361952); stn NSW482, Boyd Hill

Swamp, Kanangra-Boyd NP, 33°56.97'S 150°1.44'E, 1225 m, downstream from clumps of *Sphagnum* and sedge, 18 Nov 1992, G. Wilson & party (several, AMS C307124); stn NSW481, Boyd Hill Swamp, Kanangra-Boyd NP, 33°57.05'S 150°1.49'E, 1230 m, small aquatic plants in 10cm deep freshwater pool, 18 Nov 1992, G. Wilson & party (several, AMS C307123); stn NSW477, Roly Whalans Swamp, Morong Ck tributary, off Kanangra Rd, Kanangra-Boyd NP, 33°58.55'S 150°3.3'E, 1180 m, *Sphagnum* moss and mixed aquatic vegetation, 17 Nov 1992, G. Wilson & party (several, AMS C307112); stn NSW478, Jensens Swamp, Kanangra-Boyd NP, 33°58.65'S 150°2.76'E, 1175 m, *Sphagnum* moss and mixed aquatic vegetation, 17 Nov 1992, G. Wilson & party (several, AMS C307114); stn NSW479, Jensens Swamp, Morong Ck tributary, 1 km along track off Kanangra Rd, Kanangra-Boyd NP, 33°58.59'S 150°2.78'E, 1175 m, *Sphagnum* moss and mixed aquatic vegetation, 17 Nov 1992, G. Wilson and party (several, AMS C307119); stn NSW480, Dingo Swamp, Kanangra-Boyd NP, 33°59.52'S 150°2.31'E, 1180 m, mixed sedge, *Sphagnum* and swordgrass, 17 Nov 1992, G. Wilson & party (several, AMS C307122); stn WC7-94, Wombeyan Caves, Gap Ck, below Wombeyan Quarry, 34°19.05'S 149°57.61'E, 13 Mar 1994, WFP & GAC (1, AMS C201662); stn WC6-94, small spring on Gap Ck, below Wombeyan Quarry, Wombeyan Caves, 34°18.5'S 150°5.5'E, 13 Mar 1994, WFP & GAC (many, AMS C201675); stn WC5-94, tributary of Wollondilly River, Mares Forest Ck, Wombeyan Caves, 34°18.72'S 150°5.07'E, small spring, 12 Mar 1994, WFP & GAC (many, AMS C201682); N of Mittagong, Nattai E, at "The Crags", 34°23.62'S 150°25.37'E, 25 Apr 1994, WFP & GAC (1, AMS C204163); stn CP3-3, Murray Cave, Cooleman Plain, Kosciusko NP, 35°34.8'S 148°40.2'E, 20 Jan 1994, S. Eberhard (7, AMS C362922); stn 7, Kosciusko NP, Yarrangobilly Caves, River Cave (Y-27), 35°43.5'S 148°29.5'E, in stream gravel, 31 Oct 1980, WFP & JH (1, AMS C353946); same loc., underground stream gravel, 3 Jun 1980, K. Keck (2, AMS C362936); stn 16, Black Walters Ck, Snowy Mountains Hwy, Kosciusko NP, 35°53'S 148°32'E, side creek in roots and algae, 1 Nov 1980, WFP & JH (6, AMS C351557); stn 18, Alpine Ck, on Snowy Mountains Hwy, 8.3 km W from Providence Portal, N Lake Eucumbene, Kosciusko NP, 35°55.5'S 148°35.5'E, in side ditch, 5–8cm water, filled with grass and some algae, 1 Nov 1980, WFP & JH (3, AMS C350016; 5, AMS C353941); stn 52, Yandyguinula Ck ford, 100 m NE of Rossi-Harolds Cross Rd, on fire trail, Tallaganda SF, W of Braidwood, 35°31.5'S 149°32.1'E, 880 m, small sandy slightly stagnant creek, in dead leaves in mud in pools, 16 Jan 1981, WFP & WFPj (3, AMS C350012); stn 57, Round Mt Ck tributary, on Crow Valley Rd, 2 km S of Captains Flat-Ballalaba Rd, Tallaganda SF, SE of Braidwood, 35°38.8'S 149°31.4'E, 950 m, on weed amongst roots in small clean swift creek with sand, 16 Jan 1981, WFP & WFPj (3, AMS C350014; 12 AMS C353944); stn 59, same loc., date & coll., on weed in gentle seepage with mud (5, AMS C361987); stn 71, Reedy Ck ford, Moodong Ck tributary, Deua River tributary, on Bettowynd Fire Trail, Bendoura Ra., 35°43'S 149°41.48'E, 705 m, sedge in creek in narrow clearing in bush, 17 Jan 1981, WFP & WFPj (7, AMS C362000); stn 64, Little Crow Valley Ck tributary, on Crow Valley Creek Rd, Tallaganda SF, 35°44.16'S 149°32.33'E, 1025 m, flowing creek, sand and pebbles, 16 Jan 1981, WFP & WFPj (1, AMS C361996); Blue Lake, Mt Kosciusko, 36°24.2'S 148°19'E, 10 Feb 1977, 4 m deep, B.V. Timms (1, AMS C362925); Club Lake, Mt Kosciusko, 36°25'S 148°17.5'E, 8 Dec 1997, B.V. Timms (many, AMS C347413); Lake Albina at S end, Snowy Mountains, 36°26'S 148°17'E, 8 Feb 1977, 2 m deep, B.V. Timms (9, AMS C362929); same loc. & coll., 9 Feb 1977 (1, AMS C362928); Marble Ck, near junction of Pilot Ck and Murray River, 36°47.15'S 148°11.2'E, 11 Nov 1986, JHW (19, AMS C353948); stn 91, Deep Ck bridge, 800 m S of piggery, on lower Cadgee-Nerrigundah Rd, just above Gluf Ck, Tuross River tributary, 36°8.35'S 149°54.65'E, pools in very small side creek amongst sedge roots, 19 Jan 1981, 30, WFP & WFPj (10, AMS C362914); stn CO27, tributary of Tuross River, on Tuross Falls Rd, Badja SF, 7 km from Countgany Badja Rd, 36°12'S 149°31'E, 1000 m, 5 Nov 1990, GAC (many, AMS C353943); stn 75/7–41, Snowy Mountains Hwy, 4 km E of Steeple Flat turnoff (Tomahawk Ck?), 36°37.25'S 149°23.9'E, small, fast flowing creek, 17 Apr 1975 (1, MV F54912); stn 418E, tributary of Little Bog Ck, on Old Mill Rd, 37°9.88'S 149°5.88'E, 840 m, roots of moss and other vegetation on leaves, 22 Feb 1983, WFP & JH (many, AMS C361979). VICTORIA: stn EV3, Circular Ck. tributary, 100 m upstream from junction of Granite Ck Rd with Circular Ck Rd, N of Myrtleford, 36°26.93'S 146°47.4'E, 660 m, seepage at head of stream, 6 Dec 1988, JHW & GAC (many, AMS C350011; many, AMS C353947); stn EV8, creek, flowing into Buffalo Lake, S of Myrtleford, 36°43.23'S 146°38.67'E, 280 m, in tree fern roots, 7 Dec 1988, JHW & GAC (several, AMS C201853); Near Tatra Inn (Hotel), Mt Buffalo NP, 36°45'S 146°48'E, 4 Jan 1978, BJS (9, MV F54910); Dingo Dell, Mt Buffalo NP, 36°45'S 146°48'E, 15 Dec 1979, BJS (many, MV F54898; many, MV F54878); same loc. & coll., Acid Creek, 1 Jan 1978 (many, MV F54890); same loc. & coll., in plant debris in bog, 18 Apr 1981 (many, MV F54876); same loc. & date, *Sphagnum* bog, in silt, A. Oates & C. Hogarth (many, MV F54882); stn TA2, 19 km NE of Nillahcootie Dam, small spring at top of Watchbox Ck on Loombah Weir Rd., 36°46'S 146°11.6'E, 620 m, swamp at head of spring, very slow flow, algae and water cress plants, 20 Jan 1987, WFP JHW & GAC (10, AMS C362953); Small stream 2 km NE of junction between Native Cat Track and Nunniong Track, c. 25 km E of Benambra, 36°59'S 147°59.5'E, fast flowing stream, under leaves and bark, in silt and debris, 30 Dec 1976, R. Plant (12, MV F54911); stn VIC38, tributary of Loddon River, 1.3 km along road to Lyonville Mineral Springs, Wombat SF, E of Daylesford, 37°22.383'S 144°15.817'E, on roots, weeds and leaves, 20 Feb 1994, GAC & ACM (10, AMS C302500); stn VIC39, small tributary of Riddle Ck, corner of Cherokee-Kerrie Rd, Cherokee, E of Mt Macedon, 37°23.417'S 144°38.217'E, in roots, 20 Feb 1994, GAC & ACM (1, AMS C302492); Lerderderg River, 3.8 km WNW of Blackwood, 37°27.5'S 144°16'E, 23 May 1984, A.J. Boulton (7, MV F54896); Fireplace Ford, Lerderderg River, 3.8 km WNW of Blackwood, 37°27.5'S 144°16'E, 16 Aug 1983, A.J. Boulton (8, MV F52152); stn EV12, Tin Ck, tributary of Acheron River, near Buxton, 37°25.15'S 145°40.183'E, 320 m, in short turf-like weed at edges, 8 Dec 1988, JHW & GAC (many, AMS C362948); Acheron River, E of Healesville, 37°30'S 145°41'E, 11 Feb 1988, I. Doeg (4, MV F54892); summit of Lake Mount, 37°30'S 145°53'E, *Sphagnum* bogs, 30 Oct 1980, BJS & party (many, MV F54897); Echo Flat, summit of Lake Mountain, 37°30'S 145°53'E, bog, 15 Feb 1983, BJS & party (many, MV F54908); Lake Mountain, 37°30'S 145°53'E, bog, 24 Jan 1982, BJS (7, MV F54875); same loc., *Sphagnum* bog covered in snow and ice, 31 Jul 1981, BJS & R. Plant (many, MV F54885); same loc., *Sphagnum* bog, deep layers, 6 Mar 1982, BJS (many, MV F54883); same loc. and coll., *Sphagnum* bog, 26 Jun 1980 (many, MV F54877), 20 Mar 1980 (many, MV F54879), 24 Jan 1980 (many, MV F54880), 16 Dec 1979 (many, MV F54881), 2 Dec 1979 (many, MV F54884); stn EV13, tributary of Maroondah River, tributary of Acheron River, 37°32.68'S 145°40.13'E, 360 m, seepage at head of stream, very slow flow, duckweed and sedges, GAC (many, AMS C362966); Running Creek, Kinglake, 37°34'S 145°13'E, Oct 1977, A. Fletcher (3 decalcified, MV F54901); same loc. & coll., Jul 1977 (1, MV F54900; 1, MV F54902; 1 decalcified fragment, MV F54917; 1, MV F54915); same loc. & coll. (1, MV F54899); same loc. & coll., 3 Apr 1977 (1, MV F54919; 1 decalcified, MV F54918); Acheron River, 13 km E of Healesville, 37°38'S 145°43'E, 22 Feb 1975, L. Macmillon (2 decalcified, MV F54914); same loc., Jul, 1975, BJS & party (MV F29973); Acheron River, 18 km E of Healesville, 37°39.5'S 145°44'E, Jun 1970, L. Macmillon (2, MV F54894); same loc. & coll., 23 Feb 1975 (1, MV F54321); stn TA17, small creek, 1.4 km out of Warburton on Mt Donno Buang Rd, 37°44.883'S 145°42.3'E, 280 m, in dead leaves on edges of steam, 21 Jan 1987, WFP JHW & GAC (9, AMS C362950); stn EV14, Tomahawk Ck, S of Warburton, 37°54.183'S 145°34.133'E, 200 m, flooding, 9 Dec 1988, JHW & GAC (8, AMS C362944); stn EV11, tributary of Delatite River, on road to Mt Stirling, 37°6.52'S 146°26.2'E, 740 m, in leaf litter and debris of flooded stream, 8 Dec 1988, JHW & GAC (1, AMS C362969); stn EV10, tributary of Delatite River, on Mt Buller Rd, 37°6.65'S 146°23.333'E, 600 m, on leaves and roots of ferns, 8 Dec 1988, JHW & GAC (many, AMS C350008; 16, AMS C353949); stn EV9, tributary of Timbertop Ck, near Merrijig, 37°7.3'S 146°16.85'E, 450 m, under rocks and in weed, 8 Dec 1988, JHW & GAC (2, AMS C362960); stn TA11, 49 km S of Mansfield, 1.6 km N of A1 Mine Settlement, 1.4 km S of Goffneys Ck, tributary of Raspberry Ck, 37°30.483'S 146°11.983'E, 640 m, small stream, on and under duckweed, on surface of water, 20 Jan 1987, WFP JHW & GAC (many, AMS C362957); Mt Baw Baw, 37°50'S 146°17'E, running bog, 27 May 1976, J. McAuley (14, MV F54893); same loc., *Sphagnum* bog, on liverworts in free water, 30 Aug 1976, J. McAuley (many, MV F54891); stn VIC49, Boundary Ck, at road crossing, S of Wulgulmerang, 37°7.54'S 148°14.07'E, 900 m, 22 Feb 1994, GAC & ACM (many, AMS C302511); stn EV317, Bonang River tributary, 5 km N of junction with Gap Rd, on Bonang Hwy, 37°12.67'S 148°44.5'E, 820 m, 21 Feb 1990, WFP DLB & RdK (18, AMS C350009); 420 m E, Craigie Bog Ck, on Bendock Rd, off Coast Range Rd, 37°13.08'S 149°3.35'E, 910 m, small pool in creek bed, 22 Feb 1983, WFP & JH (4, AMS C362973); stn VIC5, upper tributary of

Fiery Ck, c. 8 km NW of Raglan on road to Warrak, 37°20.117'S 143°16.917'E, in leaves, roots, 15 Feb 1994, GAC & ACM (12, AMS C302377); stn EV303, 10 Mile Ck, at Cape Liptrap, near Waratah Bay, 38°49.33'S 145°56.2'E, 16 Feb 1990, WFP & RdK (many, AMS C351555); TA 147, tributary of Turtons Ck on Boolarra–Foster Rd (6.2 km N of intersection with Turtons Ck Rd), 38°33.783'S 146°14.5'E, 380 m, under and on leaves, 9 Feb 1987, WFP & GAC (many, AMS C353945); Traralgon Ck, on Traralgon Ck Rd, 38°29'S 146°26'E, 26 Feb 1974, WFP & GAC (1, AMS C362964).

Material identified as G. hedleyi *by B.J. Smith but now decalcified and unidentifiable*. VICTORIA: Bogong High Plains, 36°54'S 147°16'E, Feb 1978, A. Fletcher (2, MV F54920); Toorongo River, 3 km N of Toorongo Rd, 37°51.8'S 146°2.4'E, swamp, Dec 1978 (1, MV F54913); Latrobe River, 9.8 km W of Noojee, 37°53.4'S 145°54.1'E, 14 Aug 1979 (6, MV F54895); Acheron River (see above); Buffalo Ck, Mt Buffalo, 36°43.5'S 146°46'E, Apr 1978, A. Fletcher (3, MV F54922); Running Creek, Kinglake (3 lots—see above); Masons Falls, Kinglake NP, 37°30'S 145°15'E, 20 Oct 1976, A. Neboiss (1, MV F54889).

Diagnosis. Shell with rounded whorls, rarely with weak mid-dorsal angulation; sculpture of fine growth lines only. Protoconch microsculpture of pustules in initial part, remainder smooth. Radula with anterior articulatory thickenings of central teeth larger than posterior; lateral elements well spaced.

Description. Shell (Figs. 1, 2A–F) small (usually up to 2 mm in max. diameter, rarely up to 2.8 mm), orthostrophic, near planispiral, of up to 2.8 typically evenly convex whorls (in a few populations whorls weakly angulate mid dorsally—Fig. 1G,J). Protoconch (Fig. 2A–F) of 1.1–1.3 whorls, divided into an initial portion of about 0.6–0.8 whorls sculptured with distinct pustules and divided off from remainder of protoconch by distinct demarcation; remainder of protoconch with simple growth lines and, in some specimens, a few irregular, low axial ribs. Teleoconch sculpture of fine axial growth lines. Dorsal surface of whorls typically evenly convex but weak dorsal subangulation in some specimens (e.g., Tuross River and Yandyguinula Ck); inclined near suture forming moderately deep sutural excavation; periphery of last whorl evenly convex; ventral surface of last whorl evenly convex. Base with whorls evenly convex, with broad, shallow umbilicus; ratio of umbilical width to maximum diameter 0.56–0.67 (mean 0.61, n = 10). Aperture typically slightly pyriform, narrower above where it folds slightly inwards over parietal wall; rarely subcircular (examined using SEM from AMS C350016 [5], AMS C350008 [5], AMS C350009 [4], AMS C350014 [4], AMS C350011 [5], AMS C350012 [4], AMS C350018 [6], AMS C353942 & AMS C351556 [14]). Colour yellowish-white to pale yellow-brown.

Dimensions. See Table 1.

Operculum (Ponder, 1986, fig. 1F,G; Fig. 3A–F,I) subcircular (width/length mean 0.83 [n = 20], range 0.76–0.92; mean of Terrace Creek specimens [n = 8] 0.81, range 0.76–0.86), flat to very slightly concave, of 3.5–3.8 (mean 3.7, n = 11) whorls (1.5–1.8 adult), width of last whorl/length of operculum 0.22–0.37 (mean 0.29, n = 12). Nucleus large, 0.33–0.40 (mean 0.38, n = 12) length of operculum, subcentral to eccentric, spiral (of about 2 whorls), with moderately raised ridge for about 0.5–1.5 whorls on nucleus on inner surface. Exterior with about 10–25 rather irregular rows of spirally arranged pustules on last whorl (examined using SEM AMS C350016 [2], AMS C350008 [2], AMS C350009 [2], AMS C350014 [2], AMS C350011 [2], AMS C350012 [1], AMS C350018 [2], AMS C353942 & AMS C351556 [8]).

Radula (Meier-Brook & Smith, 1976, figs. 9–11; Ponder, 1986, fig. 8a–e; Fig. 4A–E) of 25 rows (Meier-Brook & Smith, 1976; Ponder, 1986). Central teeth with 7–9 (usually

Table 1. Shell measurements of *Glacidorbis hedleyi*.

dmin	dmax	mdht	mxht	aph	apw	whl
lectotype						
1.23	1.48					2.20
paralectotypes						
0.99	1.24	0.35	0.54	0.59	0.47	2.20
1.10	1.33	0.39	0.57	0.60	0.46	2.20
0.87	1.10	0.33	0.47	0.53	0.45	2.00
1.08	1.31	0.37	0.55	0.59	0.49	2.10
0.93	1.15	0.34	0.50	0.56	0.47	1.85
1.13	1.39	0.34	0.53	0.54	0.47	1.85
1.12	1.36	0.37	0.54	0.57	0.47	2.20
1.06	1.35	0.37	0.60	0.49	0.47	2.25
1.02	1.25	0.37	0.51	0.51	0.48	2.10
1.05	1.27	0.34	0.54	0.58	0.47	2.00
figured specimens (AMS C350008)						
1.49	1.74	0.47	0.82	0.79	0.63	2.25
1.62	2.00	0.56	0.83	0.79	0.73	2.65
1.28	1.58	0.46	0.77	0.70	0.63	2.25
figured specimens (AMS C350009)						
2.29	2.85	0.76	1.03	1.00	0.91	2.80
1.91	2.27	0.66	1.13	0.89	0.82	2.75
1.73	2.12	0.54	0.94	0.92	0.79	2.40
figured specimens (AMS C350011)						
1.55	2.02	0.48	0.87	0.77	0.72	2.35
1.50	1.84	0.49	0.80	0.75	0.62	–
1.25	1.60	0.39	0.73	0.65	0.58	2.15
figured specimens (AMS C350012)						
1.51	1.85	0.55	0.77	0.75	0.63	2.45
1.63	1.90	0.58	0.85	0.85	0.65	2.50
1.60	1.88	0.54	0.79	0.79	0.62	2.40
figured specimens (AMS C140426)						
1.84	2.18	0.59	0.83	0.82	0.74	3.00
1.66	2.03	0.55	0.80	0.81	0.68	2.55
1.69	2.03	0.58	0.83	0.80	0.72	2.40
figured specimens (AMS C350016, Alpine Creek)						
1.25	1.55	0.42	0.69	0.68	0.59	2.25
0.96	1.19	0.34	0.60	0.58	0.45	2.00
1.15	1.38	0.39	0.68	0.66	0.55	1.95
figured specimens (AMS C350018)						
1.58	2.00	0.57	0.90	0.88	0.74	2.25
1.61	2.04	0.51	0.83	0.82	0.75	2.20
1.58	1.97	0.52	0.86	0.81	0.77	2.30
1.64	2.07	0.58	0.86	0.84	0.76	2.30

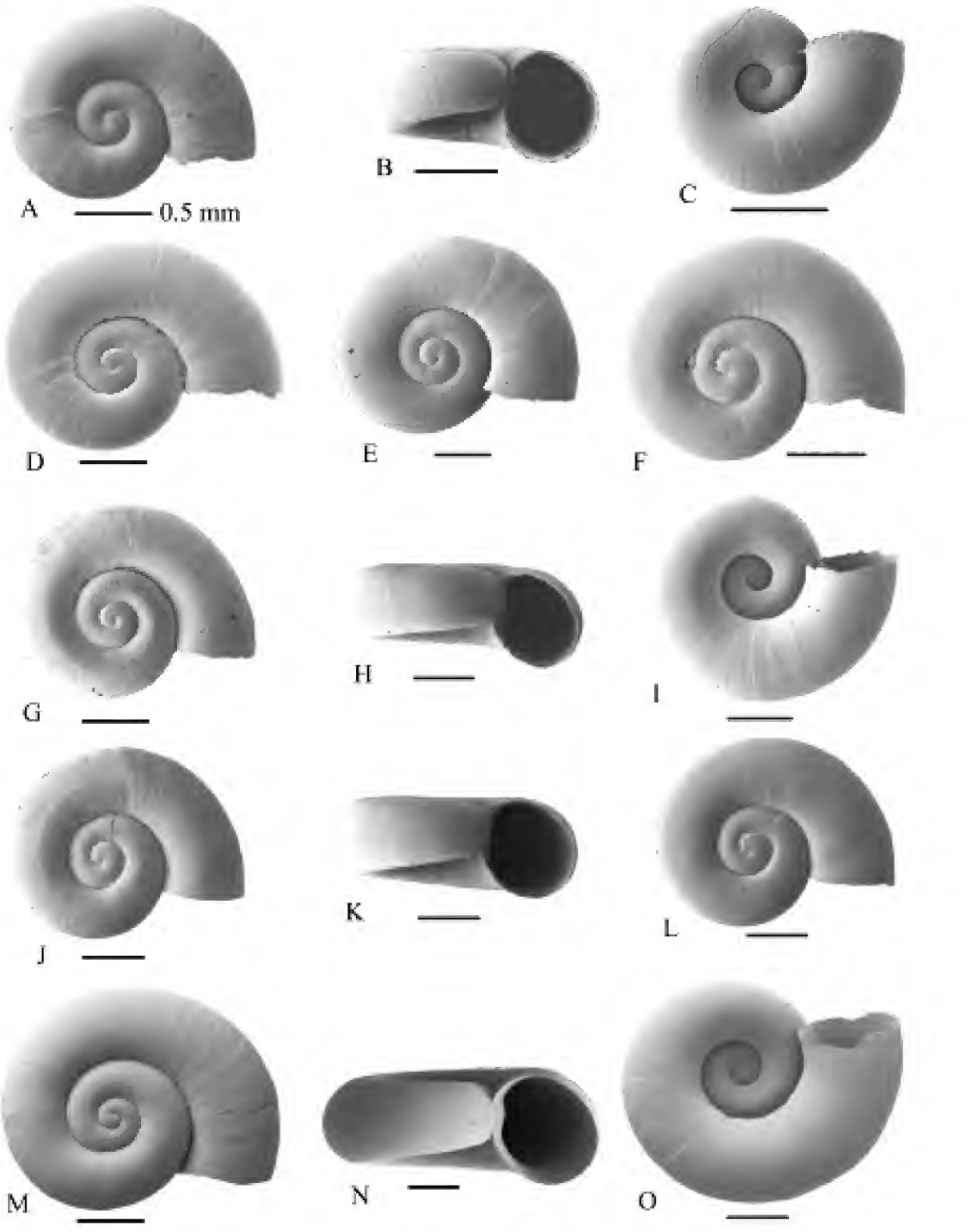


Figure 1. Shells of *Glacidorbis hedleyi*. A–C: Alpine Ck, on Snowy Mountains Hwy, Kosciuszko NP, NSW (AMS C350016); dorsal, lateral and ventral views of three specimens. D: Circular Ck, N of Myrtleford, Victoria (AMS C350011). Dorsal view. E,H: Dawson Spring, Mt Kaputar, NSW (AMS C140426); dorsal and lateral views of two specimens. F: tributary of Delatite River, on Mt Buller Rd, Victoria (AMS C350008); dorsal view. G,I: Yandyguinula Ck, Tallaganda SF, W of Braidwood, NSW (AMS C350012); dorsal and ventral views of two specimens. J–L: tributary of Tuross River, on Tuross Falls Rd, Badja SF, NSW (AMS C350018). Two dorsal and one lateral view of three specimens. M–O: tributary of Bonang River, on Bonang Hwy, Victoria (AMS C350009); dorsal, lateral and ventral view of three specimens.

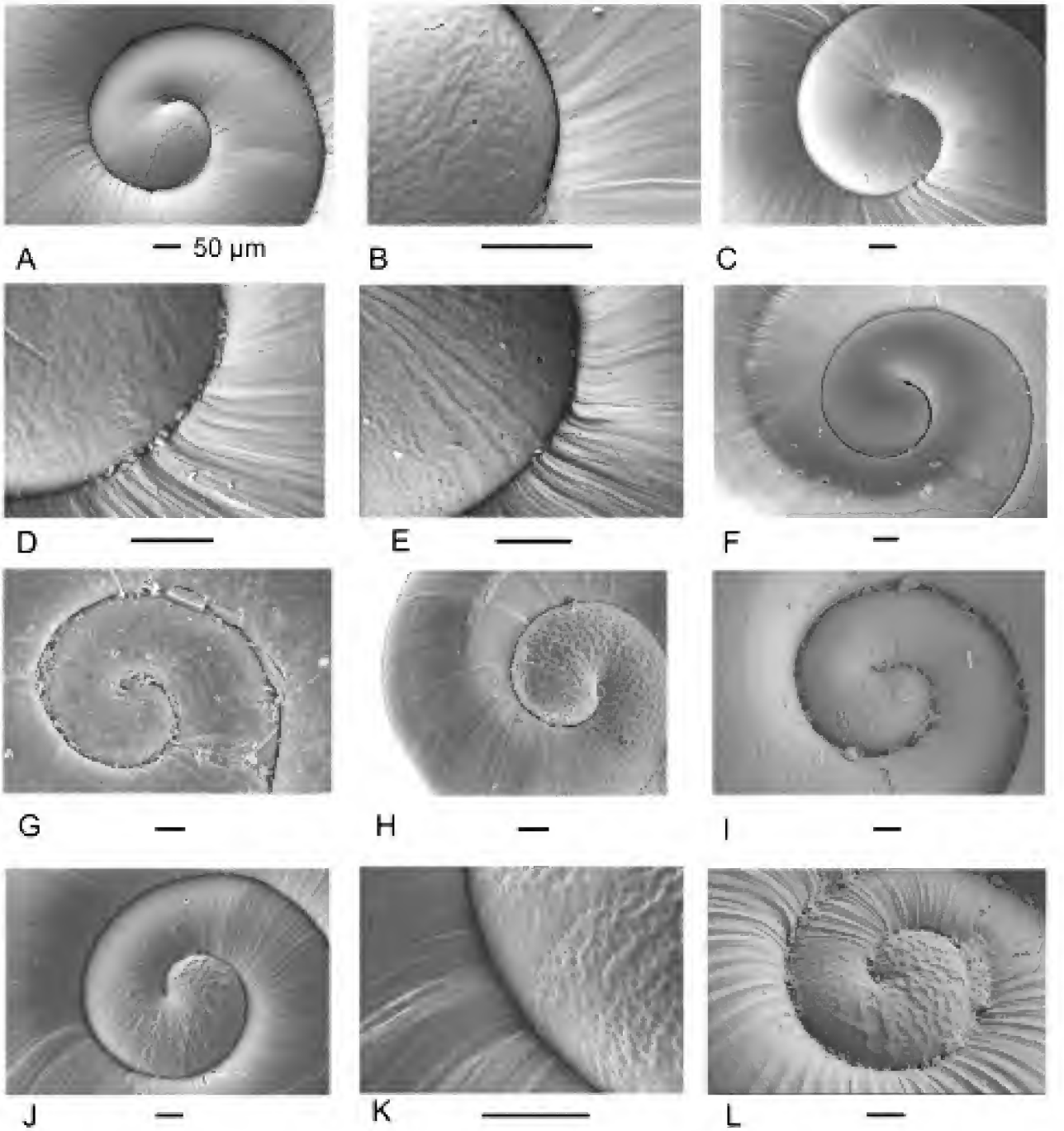


Figure 2. Protoconchs of *Glacidorbis*. A–E: *Glacidorbis hedleyi*. A,B: tributary of Bonang River, on Bonang Hwy, Victoria (AMS C350009); detail of microsculpture (B). C,D: tributary of Tuross River, on Tuross Falls Rd, Badja SF, NSW (AMS C350018); detail of microsculpture (D). E: Alpine Ck, on Snowy Mountains Hwy, Kosciuszko NP, NSW (AMS C350016). F: *Glacidorbis isolatus* n.sp., holotype (AMS C351676). G: *Glacidorbis occidentalis*; Munyerring Brook, NE of Perth, WA (1, AMS C365202). H: *Glacidorbis circulus* n.sp.; Marine Ck, tributary of Mersey R, NE of Railton, northern Tasmania (paratype, AMS C363863). I: *Glacidorbis troglodytes* n.sp., holotype (AMS C351666). J,K: *Glacidorbis tasmanicus* n.sp., tributary of Split Rock Ck, 2.8 km NE of Liawenee on Lake Hwy, Tasmania (paratype, AMS C350049); detail of microsculpture (K). L: *Glacidorbis costatus* n.sp., holotype (AMS C351684).

8) sharp, approximately equal-sized lateral cusps occupying about ⅔ length of mesocone. Base 1.8 wider than long and 1.3 wider than width of mesocone, outer edges straight, dorsal basal thickening moderately developed, anterior articulatory thickening strong, about twice size of posterior, anterior articulation abuts tooth in front, very slightly overlapping. Lateral elements slightly shorter than width of central teeth; width of lateral elements about 0.4 length, slightly wider laterally, with only trace of thickening on inner ends; spacing varies from about equal to about ⅓ width

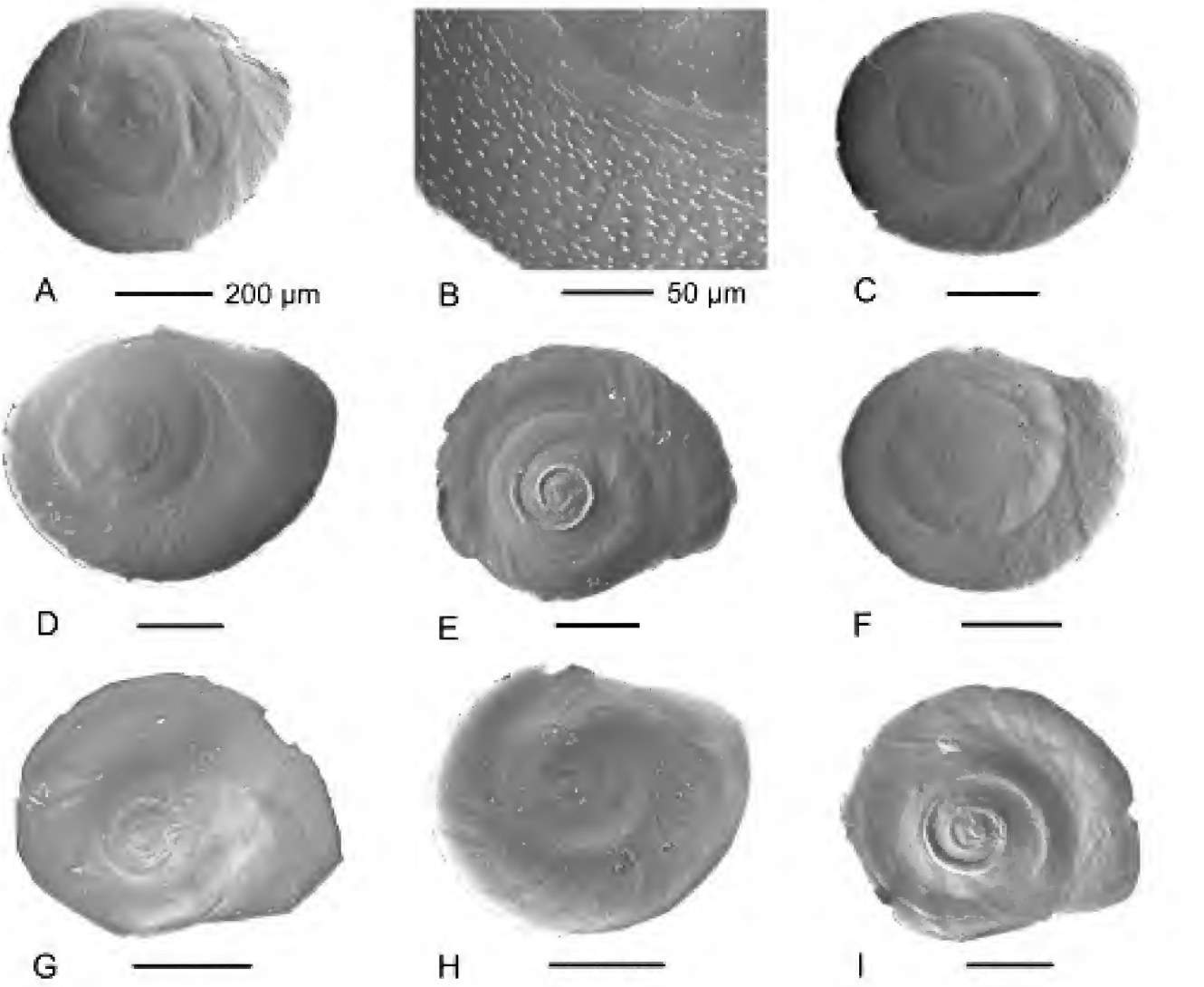


Figure 3. Opercula of *Glacidorbis* species. A–F,I: *Glacidorbis hedleyi*. A,B: Alpine Ck, on Snowy Mountains Hwy, Kosciuszko NP, NSW (AMS C350016); detail of outer surface (B). C: tributary of Round Mountain Creek, Crow Valley Rd, Tallaganda SF, SE of Braidwood, NSW (AMS C350014); outer side. D,E: tributary of Tuross River, on Tuross Falls Rd, Badja SF, NSW (AMS C350018); inner side. F,I: Dawson Spring, Mt Kaputar, NSW (AMS C140426); inner and outer sides. G,H: *Glacidorbis occidentalis*; Canning R., WA (AMS C364665); inner and outer sides. Scale bars for figures A, C–I 200 µm.

of elements and anterior edge finely serrated (description based on Alpine Creek specimens). Paralectotype with 5–7 cusps occupying about ⅔ the length of the mesocone, articulation details appear to be similar to the Alpine Creek specimens. Terrace Creek specimens reported by Ponder (1986) have 5–7 (usually 5 or 6) cusps and the base differs in being slightly wider relative to the mesocone (about 1.5–1.7) and the anterior articulation on the base is slightly more overlapped by the tooth in front. Lateral elements with finely serrated anterior edge, narrowly separated. Specimens from a tributary of Round Mt Creek, NSW, with 5–6 cusps, base of central and lateral elements similar to Alpine Creek specimens with serrated anterior edge. Base mesocone ratio 1.44. Specimens from EV317 with base to mesocone ratio 1.47–1.93, with 6–7 cusps and articulation as in the Alpine Creek specimens. EV3. Radula has 6–9 cusps on the same radula and a base to mesocone ratio of 1.64 and articulation as in the Alpine Creek specimens. Lateral elements larger and with serrated anterior edge. Mt Kaputar specimens (Fig. 4E) with central teeth with 5–7 sharp, approximately equal-sized lateral cusps occupying about ¾ or more of length of mesocone. Base about twice as wide as long, about 1.45–1.72 wider than width of mesocone, outer edges straight, dorsal basal thickening well developed, anterior articulatory thickening stronger than posterior, anterior articulation abuts tooth in front. Lateral elements about as wide as width of central teeth; width of lateral elements about 0.4 length, tapering laterally, with weakly thickened inner ends; anterior edge generally lacking any denticulation, spaced from about ¼ to ½ width apart.

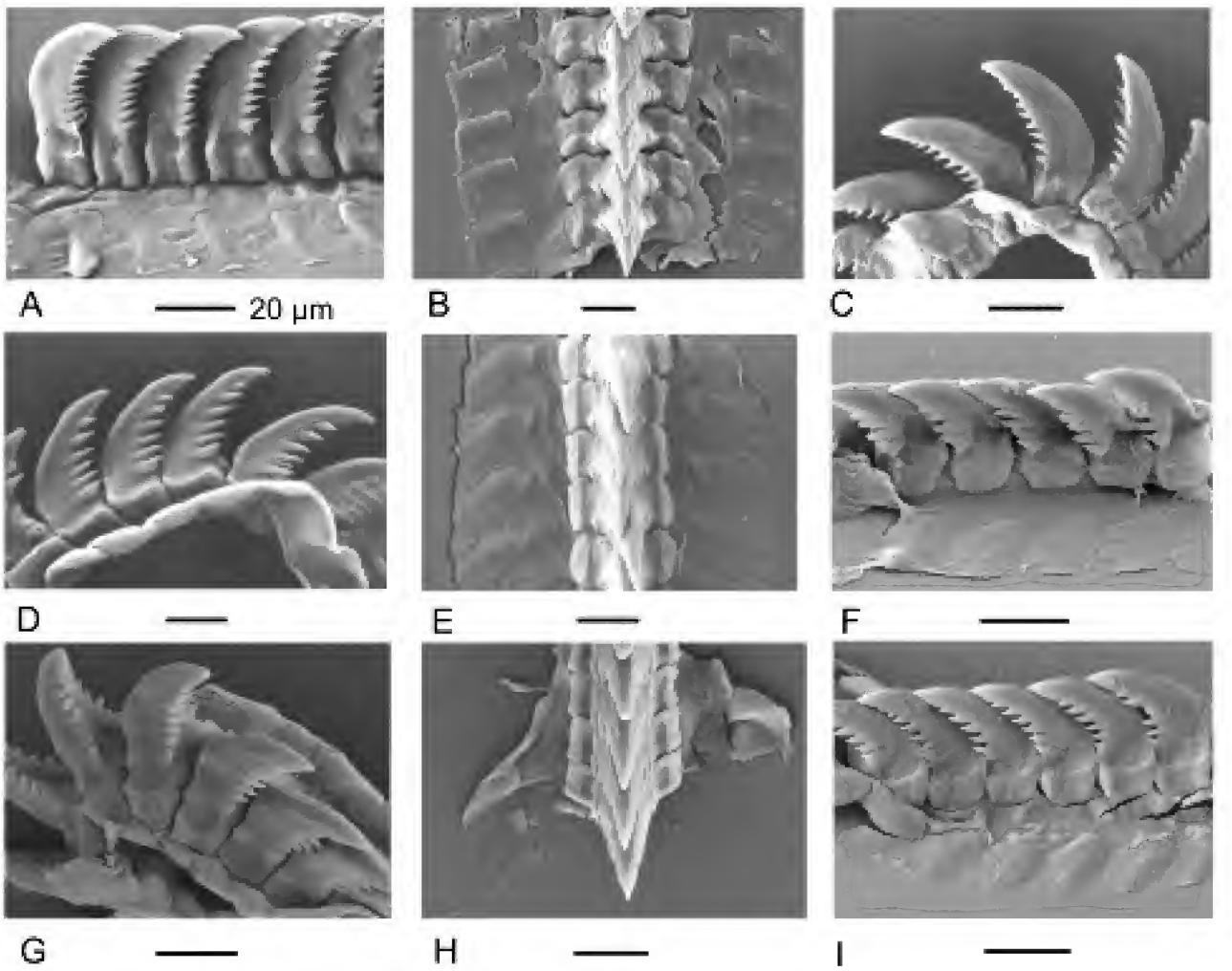


Figure 4. Radulae of *Glacidorbis*. A–E: *Glacidorbis hedleyi*. A,C: Alpine Ck, on Snowy Mountains Hwy, Kosciuszko NP, NSW (AMS C350016); lateral views. B: tributary of Bonang River, on Bonang Hwy, Victoria (AMS C350009); dorsal view. D: tributary of Tuross River, on Tuross Falls Rd, Badja SF, NSW (AMS C350018); lateral view. E: Dawson Spring, Mt Kaputar, NSW (AMS C140426); dorsal view. F: *Glacidorbis occidentalis*; Canning R., WA (AMS C364665). G–I: *Glacidorbis tasmanicus* n.sp. G: tributary of Split Rock Ck, 2.8 km NE of Liawenee on Lake Hwy, Tasmania (paratype, AMS C350049); dorsolateral view. H: McKenzies River on McKenzies Valley Rd, NE Tasmania (AMS C202222); dorsal view. I: tributary of Black Rivulet, NNE of Ringarooma, NE Tasmania (AMS C202223); lateral view.

Ovovivipary was first recorded by Smith (1979) who noted that large, well-developed embryos were present, some up to ¾ of a whorl but gave no further details. Pallial cavity contains up to nine capsules (usually less) and range in size from 0.24–0.45 mm (Ponder, 1986).

Distribution (Fig. 5). Originally described from Blue Lake, Mt Kosciuszko [Kosciusko = old spelling], this species was recorded from additional localities in the Great Dividing Range of Victoria, as far west 143°16'E (near Warrak) and southern NSW (Smith, 1979; Boulton & Smith, 1985). Ponder (1986) extended the range of this species to the Blue Mountains, near Sydney.

Ecology. Found in rivers, streams and bogs, in upland and highland areas, including intermittent rivers (Smith 1978; Boulton & Smith 1985) and streams. Boulton & Smith (1985) note that the average pH was slightly acidic (6.5–6.8) in their study sites in Victoria.

Remarks. The specimens described by Ponder (1986) are indistinguishable from the type series and other material from the Snowy Mountains in all but the radular characters noted above. These differences do not appear to be significant and additional minor variation has been observed in the other populations examined (see above). Some populations (e.g., AMS C350018 and AMS C350012 in south eastern NSW and MV F54897, AMS C353945 and AMS C362973 in Victoria) have the majority of specimens showing a weak basal angulation at the edge of the umbilicus and some have, in addition, a weak dorsal angulation at about the sutural ⅓ of the dorsal part of the whorl. These differences are not clear cut and gradation can be found from normal convex whorls to weak angulation even within

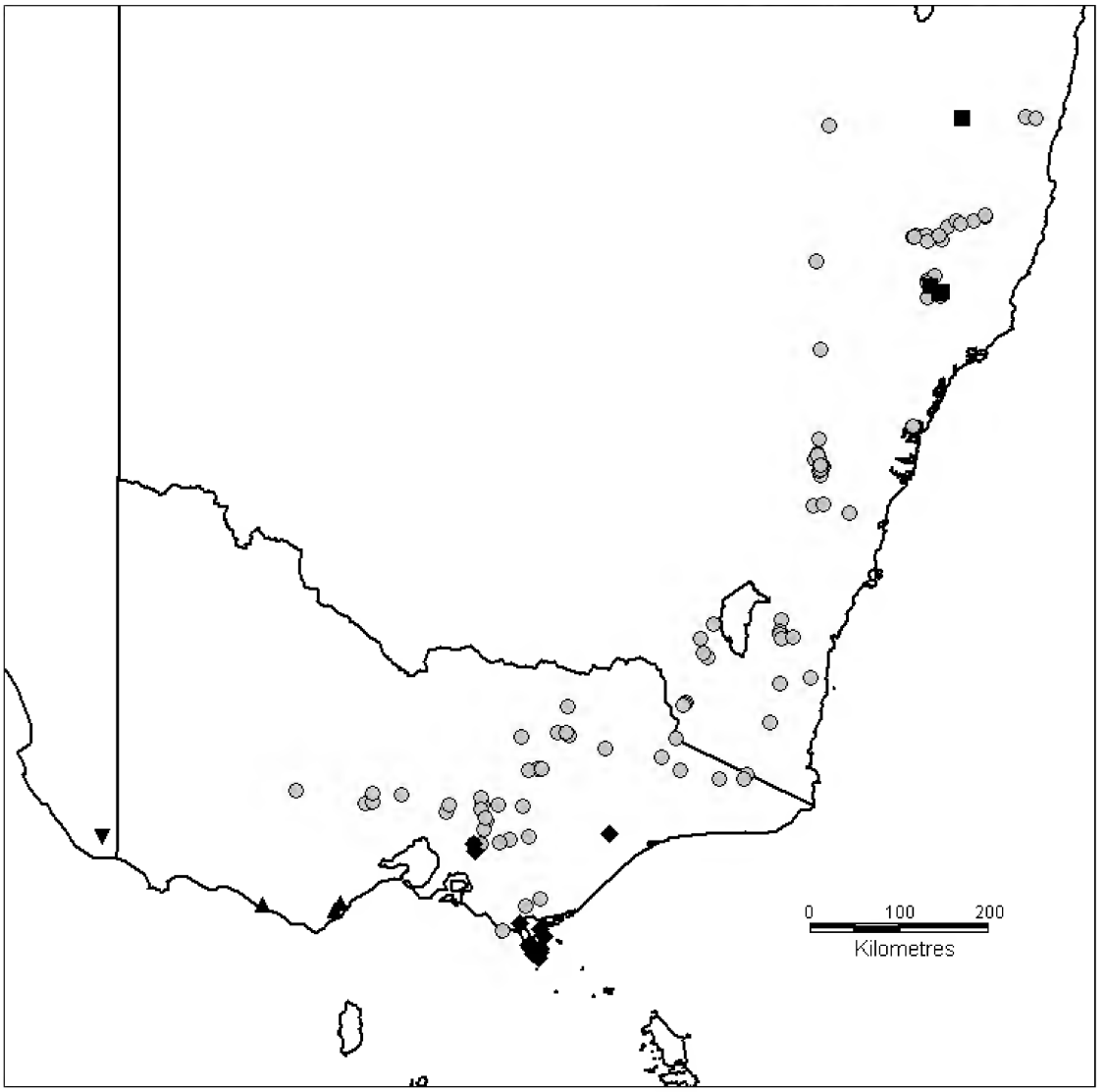


Figure 5. Distribution of *Glacidorbis hedleyi* (circles), *G. isolatus* (■), *G. rusticus* (◆), *G. otwayensis* (▲) and *G. troglodytes* (▼).

one population. In addition, the radular and opercula details show no observable differences.

The isolated Mt Kaputar material is considered to be conspecific because it cannot be separated morphologically from typical material, other than the radula having slightly wider lateral elements.

This species is unusual amongst those included in the genus in having the protoconch demarcated into two sharply divided parts, an initial pustulose portion followed by a smooth part. The former is presumably the initial larval shell and the latter that part of the shell that grows during brooding. While this same configuration is found in a new species described below from New South Wales, it has not been seen in other species. Brooding has not been observed in any other species of *Glacidorbis* and, while brooding cannot be entirely discounted, the less obvious or absent second larval shell seen in the other taxa may support the notion that these have a different reproductive strategy.

Glacidorbis occidentalis Bunn & Stoddart, 1983

Glacidorbis occidentalis Bunn & Stoddart, 1983: 50, figs. 1–7; Bunn *et al*., 1989: 25–34; Smith, 1992: 224.

Type material. HOLOTYPE, WAM 778.82. PARATYPES (5): 3, WAM 779.82; 2, WAM 780.82.

Type locality. Wungong Brook, Jarrahdale, at the Chandler Bridge (32°17'S 116°08'E), WA, S. Bunn, 21 July 1982 (holotype). Paratypes: Dillon Brook, North Dandalup, WA (32°30'S 116°04'E), S. Bunn, 23 July 1982 (WAM 779.82); Seldom Seen Brook, Jarrahdale, WA (32°16'S 116°06'E), S. Bunn, 2 July 1982 (WAM 780.82).

Material examined. WESTERN AUSTRALIA: NOT DECALCIFIED: Munyerring Brook, NE of Perth, 1 Oct 1998, B. Robson, 31°25.1'S 116°11.13'E (2, AMS C365202) (figured specimen). DECALCIFIED: stn

CD1A-4, Kangaroo Gully, Canning River, 32°6'S 116°9'E, intermittent stream, 1 Oct 1985, S. Bunn (7, AMS C362993); stns CD1A-5 & A-8, Kangaroo Gully, Canning River, 32°6'S 116°9'E, intermittent stream, 6 Aug 1985, S. Bunn (13, AMS C364665; 16, AMS C363001); stns LC 2 & 3, Araluen Rd, Canning River, 32°9'S 116°7'E, intermittent stream, 5 Jul 1985, S. Bunn (14, AMS C362996; 14, AMS C362998); stn 5, Wongung Brook, Jarrahdale, 32°10'S 115°59'E, 2 Jun 1982, S. Bunn (2, MV F54886); same loc. & coll., 31 Aug 1982, S. Bunn (7, MV F54888); stn 10, Dillon Brook, North Dandalup, 32°31'S 116°1'E, 23 Jul 1982, S. Bunn (1, MV F54887).

Diagnosis. Shell minute, with convex whorls and very fine growth lines. Protoconch with microsculpture of minute pustules. Differs from all other species in the very narrow base of the central teeth.

Description. Shell (Figs. 2G, 6G–I) very small (up to 1.2 mm in max. diameter), orthostrophic, near planispiral, of up to 2.6 whorls. Protoconch (based on AMS C365202; Fig. 2G) 1.3 whorls, initial whorl almost smooth, with weak, irregular pitting, last third whorl with traces of what appear to be a few very indistinct spiral threads. Teleoconch sculpture of weak, close growth striae. Dorsal and ventral surfaces of whorls and periphery of last whorl evenly convex. Base with broad, shallow umbilicus; ratio of umbilical width to maximum diameter 0.58. Aperture subcircular (2 specimens examined using SEM from AMS C365202). Colour of periostracum light brown.

Dimensions. See Tables 2 and 3.

Operculum (Bunn & Stoddart, 1983: 50, fig. 2; Fig. 3G,H) subcircular (width/length 0.81–0.87), flat, of about 3.5 whorls, width of last whorl/length of operculum 0.89–0.31. Nucleus large, 0.457 length of operculum, subcentral, spiral (of 2.5 whorls), initial whorl small, width relative to opercular width only 0.098. Inner surface with only suggestion of thickened ridge for about 0.5 whorls from nucleus. Exterior with scattered pustules on last whorl, approx. 20 in line from suture to edge (examined from 3 specimens from AMS C364665).

Radula (Bunn & Stoddart, 1983: 50, figs. 3–6; Fig. 4F) of 19–20 rows of teeth. Central teeth with 2–5 sharp, approximately equal-sized lateral cusps occupying about ½ to ⅔ length of mesocone. Base very narrow, only 1.14 wider than long, about 1.2 wider than width of mesocone, outer edges straight, dorsal basal thickening moderately developed, anterior articulatory thickening very prominent, posterior articulatory thickening very weak, anterior articulation slightly overlaps base of tooth in front. Lateral elements abutting, uniformly thin, about 1.5 wider than bases of central teeth, about 1.5 wider than long, not tapering, outer edge straight, anterior edge with few irregular serrations (not finely denticulate as in *G. hedleyi*) (based on Canning R., southern WA, and some details also from Bunn & Stoddart, 1983: 50, figs. 3–5) (3 radulae examined from AMS C364665).

Head-foot. Described and illustrated by Bunn & Stoddart (1983: 50, fig. 7). Similar to *G. hedleyi* but the sketch shows relatively longer cephalic tentacles and a wider snout and anterior foot. The animal varies from cream to dark grey depending on the locality (Bunn & Stoddart, 1983: 50). The animal removed from its shell is unpigmented (preserved material).

Table 2. Shell measurements of type specimens of *Glacidorbis occidentalis* from Bunn & Stoddart, 1983.

dmax	apw	whl
holotype		
0.96	0.44	2.3
paratypes WAM 779.82		
0.84	0.36	2.1
1.08	0.40	2.2
0.68	0.32	1.6
paratype WAM 780.82		
1.20	0.48	2.6

Table 3. Shell measurements of specimens of *Glacidorbis occidentalis*.

dmin	dmax	mdht	mxht	aph	apw	whl
figured specimen (AMS C365202)						
0.51	1.27	0.45	0.33	0.49	0.42	2.2
additional specimen (AMS C365202)						
0.46	1.01	0.38	0.27	0.42	0.35	2.2

Distribution. Bunn & Stoddart (1983) list several localities in close proximity near Jarrahdale when they described this species, but Bunn *et al.* (1989) added considerably more locations that extend from the south side of Perth at about 32°S south along the Darling Escarpment for nearly 60 km (see Bunn *et al.*, 1989, fig. 1).

Remarks. This species is unusual in frequenting intermittent streams in the ranges south of Perth. Its ecology has been described by Bunn & Stoddart (1983) and Bunn *et al.* (1989) and in the latter paper information is given on seasonal occurrence and size structure.

Unfortunately all of the original material that could be located, other than the types, is decalcified. The shell description provided here is based on the original data supplemented by the examination of two shells (Figs. 6G–I) from a locality north-east of Perth, whereas the material included in the original description was from south of Perth. The specimens agree well with the original description, although they are slightly larger than the type series.

Bunn *et al.* (1989) described "brooded young which appear to be released as veligers during the winter months" and that the brood pouch contained 33–218 (mean 106, n = 10) "shelled veligers" 65–83 µm in diameter along the entire length of the pallial cavity while in others the "veligers" were present in only the anterior part (2–34, mean 15, n = 9). The "veligers" were of similar size along the entire length of the brood pouch and are illustrated in Bunn *et al.* (1989, figs. 3 and 4). Examination of their slides has shown that many of the "veligers" are present in the digestive gland or loose in the pallial cavity, as can be seen in their figure 4. They are actually the pollen grains of *Pinus* sp., exotic pine

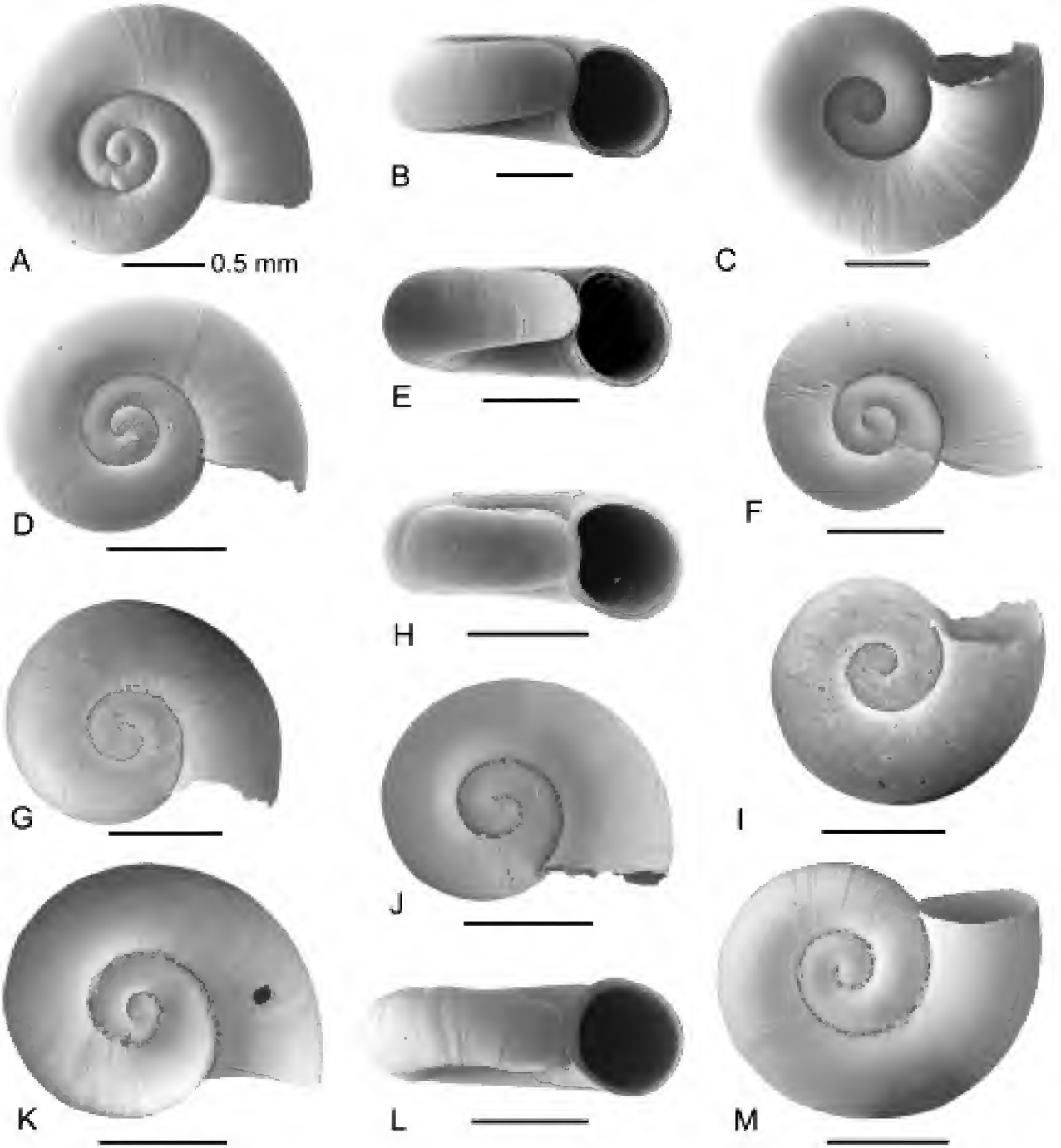


Figure 6. Shells of *Glacidorbis*. A–F: *Glacidorbis tasmanicus* n.sp. A–C: tributary of Split Rock Ck, 2.8 km NE of Liawenee on Lake Hwy, Tasmania; holotype (A) (AMS C351714); paratypes (B,C) (AMS C350049); lateral and ventral views. D: McKenzies River on McKenzies Valley Rd, NE Tasmania (AMS C202222); dorsal view. E,F: tributary of Black Rivulet, NNE of Ringarooma, NE Tasmania (AMS C202223); lateral and dorsal views. G–I: *Glacidorbis occidentalis*; Munyerring Brook, NE of Perth, WA (2, AMS C365202); dorsal, lateral and ventral views of the same specimen. J–M: *Glacidorbis troglodytes* n.sp.; One Tree Sink Hole (= Wurwurlooloo 5L7), near Mt Gambier, South Australia. J: holotype (AMS C351666); dorsal view. K–M: dorsal, lateral and ventral views of a paratype (AMS C350044).

plantations being common in the area. It is not known whether the pollen is ingested selectively or whether it is taken up accidentally while feeding on other material that is not readily detected in the gut.

While the shell, radular and opercular characters are mainly typical of the genus, unusual features include the narrow base of the central teeth of the radula and the very weak (virtually absent) internal thickening on the inner side

of the operculum. The shell is similar to *G. hedleyi* in shape and in lacking any keels or significant sculpture, although differing in its smaller size and more nearly planispiral coiling. It also has a protoconch microsculpture of minute pustules but these are smaller in *G. occidentalis*, being about 3–4 µm in diameter, compared with about 5–7 µm in *G. hedleyi*.

Two decalcified specimens of *Glacidorbis* from south Western Australia has been examined that were found in peatlands near Walpole, southern WA. These are about the same size as *G. occidentalis* but the animal is coarsely spotted with black. Confirmation of their identity must await the examination of better material. The data associated with these specimens is as follows: Yeagarup Lake, southern WA, AMG 50 396766 6177230 P. Horwitz, by net Oct 1993; Poorginup Swamp, southern WA, AMG 50 473745 6176016 in crayfish burrow, P. Horwitz, April, 1993.

Glacidorbis tasmanicus n.sp.

Derivation. Named after Tasmania.

Type material. HOLOTYPE, AMS C351714. PARATYPES: 2, AMS C350049; 6 dry and many wet, AMS C355554; 2, TM E23416; 2, QVM 9:16234.

Type locality. Stn TA130, Tributary of Split Rock Ck, 2.8 km NE of Liawenee on Lake Hwy, Tasmania, 41°52.8'S 146°41.283'E, in sedges, 7 Feb 1987, 1040 m, WFP & GAC, pH 7.26, cond. 0.01.

Additional material examined. TASMANIA: stn TA94, tributary of Ringarooma River on Gladstone Rd 3.3 km S of Gladstone, 40°59'S 148°1'E, 100 m, 30 Jan 1987, WFP JHW & GAC (many, AMS C363834); stn TA81, McKenzies River on McKenzies Valley Rd, 41°16.59'S 147°32.58'E, 300 m, seepages on banks, 28 Jan 1987, WFP JHW & GAC (many, AMS C202222); stn TA70, Pearly Brook, tributary of Great Forester River on Speck Rd, 41°4.6'S 147°39.783'E, 100 m, on tree fern roots and under stones, 27 Jan 1987, WFP JHW & GAC (2, AMS C202217); stn TA71, upper parts of Speck Ck on side road off Speck Rd, 41°4'S 147°40.683'E, 120 m, on dead leaves and tree fern roots, 27 Jan 1987, WFP JHW & GAC (1, AMS C363844); stn TA86, tributary of Black Rivulet, 200 m S of Main Ck, NNE of Ringarooma, 41°13.3'S 147°47.8'E, 500 m, in *Sphagnum* bog near stream, 29 Jan 1987, WFP JHW & GAC (many, AMS C202223); stn TA91, tributary of Frome River, E of crossing of Frame River, on Greenstone Rd, 41°8.5'S 147°53.983'E, 220 m, on leaves, 30 Jan 1987, WFP JHW & GAC (7, AMS C363738); stn TA92, tributary of Frome River on NW side, 0.5 km NE along Greenstone Rd, 41°8.2'S 147°54.183'E, 240 m, under dead leaves in faster part of stream on wood, 30 Jan 1987, WFP JHW & GAC (1, AMS C363908); stn TA101, Carters Ck tributary of Scamander River, 1 km N of Scamander River, Hogans Rd, 41°24'S 148°5.883'E, 100 m, under stones, on dead leaves in flowing water, 31 Jan 1987, WFP JHW & GAC (2, AMS C363841); stn C75T, top end of Ansons River on road between New England Rd and Cliffords Rd, NW of St Helens, 41°11.78'S 148°6.42'E, 140 m, sandy small stream, 17 Jan 1982, WFP JH & WFPj (7, AMS C363902).

Diagnosis. Similar to *G. hedleyi* but differs in having a more coarsely sculptured protoconch, with the sculpture composed of irregular pits and ridges rather than pustules. Teleoconch has a weak or absent ridge in the dorsal sutural third and the operculum has fewer whorls with more numerous pimples than in *G. hedleyi*. The radula has larger, abutting lateral elements and equal-sized articulatory thickenings anteriorly and posteriorly.

Description. Shell (Figs. 2J,K; 6A–F) small (up to 1.9 mm in max. diameter), orthostrophic, near planispiral, of up to about 3.1 convex whorls. Protoconch (Fig. 2J,K) of about 1.2–1.3 whorls, sculptured with rather irregular, distinct shallow pits. Protoconch followed by about ⅓ whorl of possible larval shell not clearly demarcated from teleoconch. Teleoconch sculpture of fine, straight, rather regular, collabral growth lines. Dorsal surface of whorls steeply inclined near suture forming moderately deep sutural excavation; periphery of last whorl evenly convex; ventral surface of last whorl evenly convex. Base with broad, shallow umbilicus; ratio of umbilical width to maximum diameter 0.65–0.70. Aperture slightly pyriform, narrower above where it folds inwards over parietal wall (9 examined using SEM, from the type locality [3], AMS C202222 [3] and AMS C202223 [3]). Colour yellowish-white.

Dimensions. See Table 4.

Operculum (Fig. 7I,J) oval (width/length 0.72–0.87, mean = 0.82, n = 5), flat, of c. 3.6 whorls (1.6 adult), width of last whorl/length of operculum 0.28–0.40. Nucleus large, 0.20–0.33 length of operculum, spiral (of about 2 whorls), subcentral. Inner surface with ridge from nucleus occupying half whorl and prominent muscle scar. Exterior with numerous (30–40+) rather irregular rows of partly spirally arranged pustules on last whorl (8 specimens examined, from the type locality [2], AMS C202222 [3] and AMS C202223 [3]).

Radula (Fig. 4G,I) of 17–22 rows. Central teeth with 3–9 (normally 5–6) sharp, approximately equal-sized lateral cusps occupying about ⅔ or a little less length of mesocone. Base 2.5–2.8 (2 in AMS C202223) wider than long, about 1.6–1.9 wider than width of mesocone, outer edges straight, dorsal basal thickening well developed, anterior and posterior articulatory thickenings about equal in strength, anterior articulation abuts tooth in front. Length of lateral elements shorter than width of central teeth; width of lateral elements about twice length, laterally tapering and curved anteriorly, with very weakly thickened inner edge; each element abuts, anterior edge distinctly denticulate (10

Table 4. Shell measurements of *Glacidorbis tasmanicus*.

dmin	dmax	mdht	mxht	aph	apw	whl
holotype						
1.64	1.89	0.52	0.85	0.81	0.71	2.60
paratypes (AMS C350049)						
1.51	1.75	0.50	0.77	0.73	0.61	2.50
1.48	1.80	0.53	0.81	0.81	0.63	2.55
figured specimens (AMS C202222)						
1.14	1.39	0.38	0.62	0.61	0.55	2.30
1.31	1.61	0.43	0.69	0.70	0.54	2.60
1.17	1.42	0.39	0.66	0.65	0.52	2.35
figured specimens (AMS C202223)						
0.95	1.19	0.33	0.53	0.50	0.46	2.20
0.80	1.02	0.30	0.51	0.49	0.40	2.00
0.84	1.07	0.30	0.50	0.47	0.37	2.00

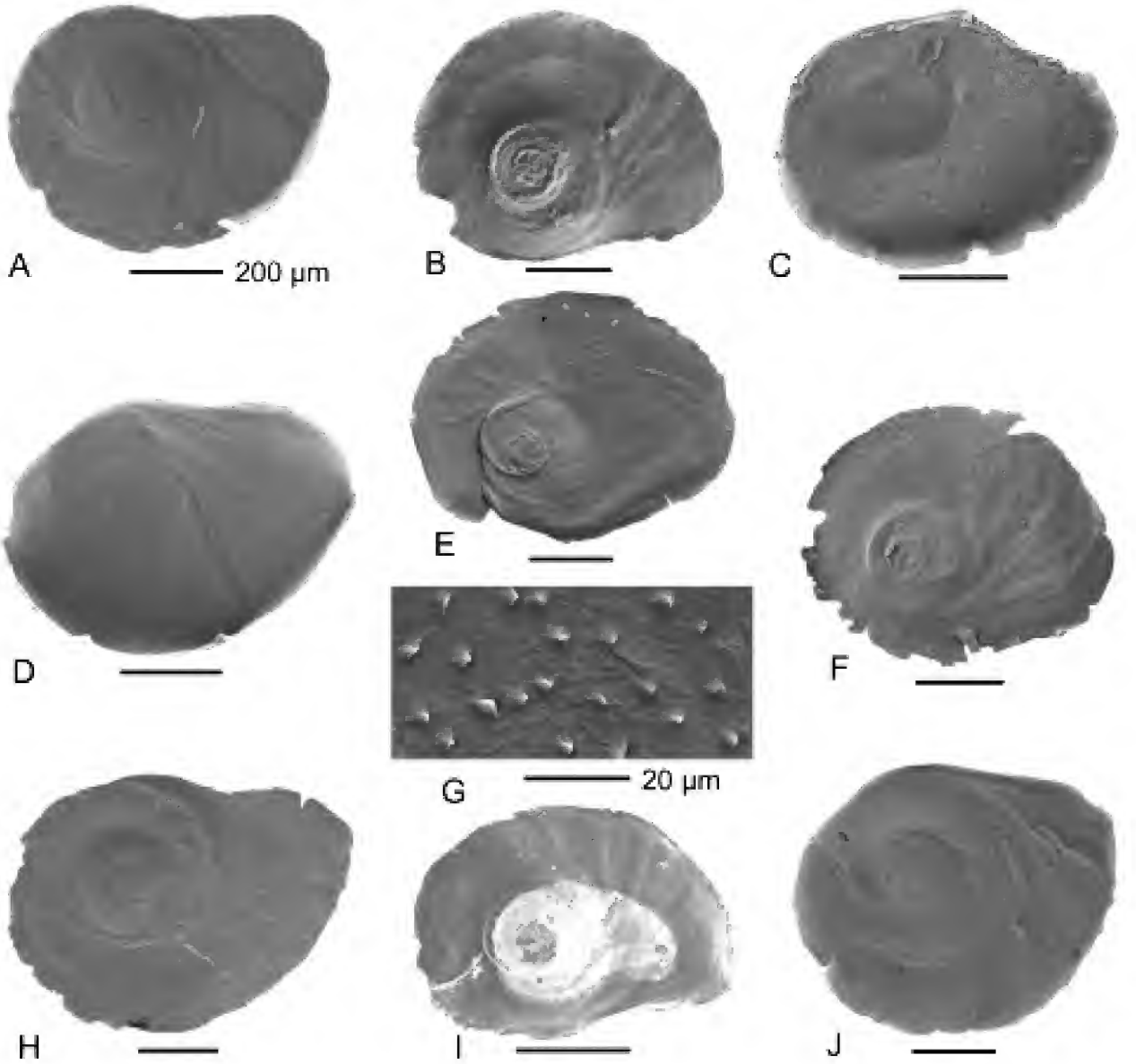


Figure 7. Opercula of *Glacidorbis*. A,B: *Glacidorbis catomus* n.sp.; Hurst Ck, at Oakdene Rd, W of Scottsdale, Tasmania (paratypes, AMS C350050); outer and inner sides. C,F: *Glacidorbis atrophus* n.sp.; tributary of Big Ck, off Tram Rd, S of Wynyard, NW Tasmania (paratype, AMS C202354); outer and inner sides. D,E: *Glacidorbis decoratus* n.sp.; tributary of Mosquito Ck, on Corner Rd, NW Tasmania (AMS C350046); outer and inner sides. G,H: *Glacidorbis rusticus* n.sp.; Squeaky Ck, Wilsons Promontory, Victoria (paratype, AMS C350047); outer side (H); detail of outer surface (G). I,J: *Glacidorbis tasmanicus* n.sp. I: McKenzies River on McKenzies Valley Rd, NE Tasmania (AMS C202222); inner side. J: tributary of Split Rock Ck, 2.8 km NE of Liawenee on Lake Hwy, Tasmania (paratype, AMS C350049); outer side. Scale bars for figures A–F and H–J 200 µm.

specimens examined, from the type locality [4], AMS C202222 [3] and AMS C202223 [3]).

Distribution (Fig. 8). This species is known from several localities in NE Tasmania and one on the Central Plateau.

Remarks. This species is similar to *G. hedleyi* from Victoria and New South Wales in teleoconch and radular characters. It differs in having a strongly pitted protoconch microsculpture, not pustulate, and lacking a distinct secondary larval portion of the protoconch (although there is a suggestion of this in some specimens for about a third of a whorl, it is not clearly defined as in *G. hedleyi*). Unlike *G. hedleyi*, there is no evidence of brooding in *G. tasmanicus*, although relatively few specimens of the latter species have been examined.

Given the disjunct distribution of this species, reduction of keeling in more than one lineage may have resulted in independently similar shell morphologies. Some variation

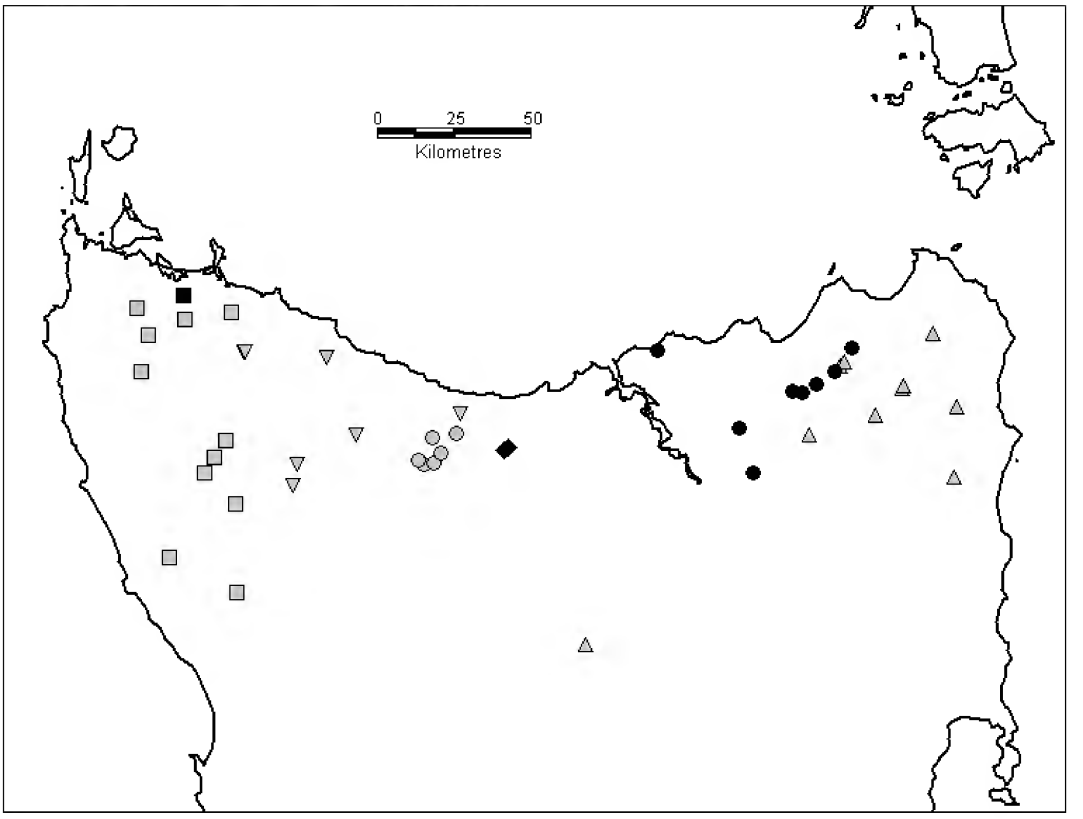


Figure 8. Distribution of *Glacidorbis tasmanicus* (shaded △), *G. costatus* (■), *G. circulus* (◆), *G. decoratus* (shaded □), *G. catomus* (●), *G. atrophus* (shaded ▽) and *G. bicarinatus* (shaded ○).

occurs within the NE; for example specimens from a tributary of Black Rivulet (AMS C202223) are smaller than those in the other two series (see measurements) but the ratios of the shell measurements are similar, as are the details of the radula and operculum. In the absence of distinctive shell microsculpture or other evidence to separate them, all these populations are regarded as conspecific.

The only other almost smooth-shelled species previously described from Tasmania is *G.* pawpela* from Great Lake. One population of *G. tasmanicus* was taken from a stream on the edge of Great Lake but these two species differ, however, in several characters, including size (*G. pawpela* is twice the size, reaching 3.1 mm in maximum diameter compared with 1.6 in *G. tasmanicus*), shell morphology, the whorls more rapidly increasing in width in *G. pawpela* (diameter of last whorl/diameter of shell in *G. pawpela* = 0.41 compared with 0.32–0.38 in the populations attributed to *G. tasmanicus* [0.32 in the Great Lake population]) so that it reaches a greater diameter and has about the same number of whorls. The last whorl is more steeply inclined towards the dorsal suture in *G. pawpela* than in *G. tasmanicus* (cf. Fig. 15A and 6A,D,F). The radula differs considerably in the two species, with *G. pawpela* having 17–18 denticles along most of the edge of the mesocone whereas in *G. tasmanicus* the 3–7 teeth occupy ⅔ or less of the length of the mesocone.

* Placed in *Benthodorbis* below.

Glacidorbis bicarinatus species group

The following six species from northern and NW Tasmania and coastal Victoria typically have a distinctly bicarinate shell, the dorsal (and usually the ventral) carina forming a distinct angulation of the whorl. The protoconch microsculpture consists of pits. These taxa are nearly all allopatric and relatively small, but apparently consistent differences separate them.

Glacidorbis bicarinatus n.sp.

Derivation: *bi* (Latin)—two, *carinatus* (Latin)—keeled.

Type material. HOLOTYPE, AMS C351694. PARATYPES (18): 2, AMS C202347; 5, AMS C354949 (dry); 9, AMS C364669 (wet); 1, QVM 9:1643; 1, TM E23417.

Type locality. Stn TA512B, 3 km E of Preston, West Gawler, Tasmania, 41°17.22'S 146°5.85'E, Roots, moss, liverworts and leaves, 5 Feb 1989, 260, WFP JHW & FEH, pH 6.42, cond. 0.06.

Additional material examined. TASMANIA: Stn C108T, Buttons Rivulet on South Preston Rd, 41°21.117'S 146°2.767'E, 500 m, in weed and under stones, 20 Jan 1982, WFP JH & WFPj (4, AMS C363899); Castra Rivulet, S of Upper Castra, S of Ulverstone, 41°21.62'S 146°6.07'E, treeferns, duckweed, roots, etc., 16 Jan 1992, WFP & JMP (many, AMS C203829);

stn TA506, Upper Castra, Heathcote Ck (trib. of East Gawler R.) on Castra Rd, 41°19.78'S 146°7.93'E, 400 m, on stones, 4 Feb 1989, WFP JHW & FEH (1, AMS C202343); Nietta Ck, S of Ulverstone, tributary of Castra Rivulet, Wilmot River, 41°21.83'S 146°4'E, medium creek, with stony bed, 16 Jan 1992, WFP & JMP (1, AMS C201448); TA 514, top end of Viking Ck, tributary of Wilmot River, 41°16.383'S 146°11.283'E, 220 m, leaves and pieces of small wood, 5 Feb 1989, WFP JHW & FEH (2, AMS C363904); stn TA515B, tributary of Little Clayton's Rivulet, 41°13'S 146°12.28'E, 120 m, on leaves and stones, 5 Feb 1989, WFP JHW & FEH (3, AMS C202485).

Diagnosis. Dorsal carinae strong, raised as strong cord, at about sutural ⅓ to ½, ventral carina strong, in middle of base; microsculpture of weak to moderate costae on first whorl, otherwise weak growth lines and extremely fine spiral threads, latter mostly visible only in transmitted light. Radula with 8–9 cusps and overlapping articulation.

Description. Shell (Figs. 9C,D; 10A–C,E,L) small (up to 1.9 mm in max. diameter), orthostrophic, near planispiral, up to about 2.7 bicarinate whorls. Protoconch (Fig. 9C,D) of about 1.0–1.2 whorls, sculptured with shallow, irregular pits, borders of pits irregular and narrow. Protoconch followed by about ⅓ whorl of possible larval shell not clearly demarcated from teleoconch. Teleoconch microsculpture of fine growth lines, first whorl with weak to moderate costae; prominent raised keel in middle of whorl; base with strong keel on middle of whorl. Dorsal surface of whorls on sutural side of keel strongly sloping into suture; periphery of last whorl evenly convex; outer ventral surface of last whorl convex, inside keel flat and sloping to umbilicus. Base with broad, shallow umbilicus; ratio of umbilical width to maximum diameter 0.69. Aperture subcircular (3 specimens examined using SEM from type locality). Colour pale yellow-white to white, opaque to slightly semi-translucent.

Dimensions. See Table 5.

Operculum oval (width /length 0.80–0.84), flat, of c. 3.4 (c. 1.4 adult) whorls; width of last whorl/length of operculum 0.40. Nucleus large, 0.42 length of operculum, spiral (about 2 whorls), eccentric. Inner surface with slightly raised spiral ridge surrounding part of nucleus. Exterior with numerous approximately spirally arranged pustules on last whorl (3 specimens examined from type locality).

Radula (Fig. 11A,B) of 21–22 (n = 3) rows. Central teeth with 8–9 sharp, approximately equal-sized lateral cusps occupying about ¾ length of mesocone. Base wider than long (width/length 0.39–0.42), 1.7 to about twice width of mesocone, outer edges slightly concave to slightly convex, dorsal basal thickening prominent, anterior articulatory thickening stronger than posterior, anterior articulation slightly overlapped by dorsal part of posterior articulatory area of tooth in front. Width of lateral elements about half their length, not tapering, straight to slightly curved, with posterior edge of inner ends weakly thickened; plates abutting to narrowly separated, anterior edges finely denticulate (3 radulae examined from type material).

Table 5. Shell measurements of *Glacidorbis bicarinatus*.

dmin	dmax	mdht	mxht	aph	apw	whl
holotype						
1.56	1.88	0.53	0.81	0.75	0.65	2.65
paratypes (AM C202347)						
1.29	1.54	0.49	0.81	0.78	0.58	2.25
1.36	1.59	0.50	0.82	0.75	0.59	2.40

Distribution (Fig. 8). Mid north coast, in tributaries of Gawler River.

Remarks. The material attributed to this species is very constant over the small area it occupies. It is contrasted with the other species of the *G. bicarinatus* species group that are described below in the remarks for those taxa.

Glacidorbis catomus n.sp.

Derivation: *catomus* (Latin)—shoulder, refers to the shouldered whorls.

Type material. HOLOTYPE, AMS C350957. PARATYPES (additional paratypes are listed below): 18 dry and many wet, AMS C202214; 2, QVM 9:1644; 2, TM E23418.

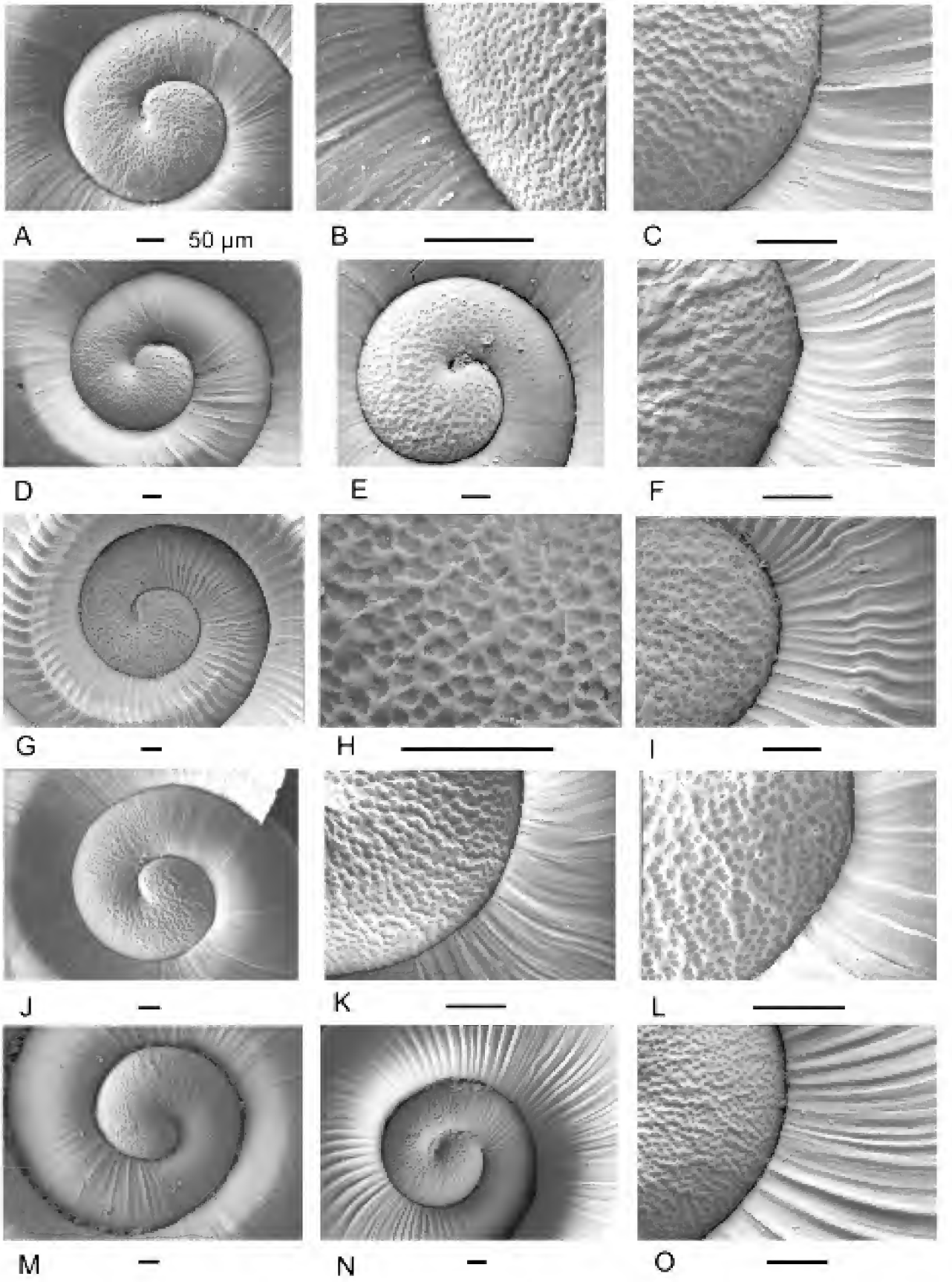
Type locality. Stn TA68, Monazite Ck, tributary of Surveyors Ck on Old Waterhouse Rd, NE Scottsdale, 41°7.77'S 147°34.2'E, 130 m, 27 Jan 1987, WFP JHW & GAC.

Additional paratypes. Stn JW27, Hurst Ck, at Oakdene Rd, 2.5 km W of Scottsdale, 41°9.38'S 147°30.92'E, 100 m, root mats, leaf litter, gravel, 8 Feb 1988, JHW (5, AMS C202329; 6, AMS C363894); stn TA706, same locality, in boggy weed, 5 Feb 1995, SAC & ACM (many, AMS C203970); stn TA67, near tree fern roots in seepage, 27 Jan 1987, WFP JHW & GAC (3, AMS C350050; 1, AMS C351675, many, AMS C353992).

Additional material examined. TASMANIA: stn TA60, Curries River on Beechford Rd 4.9 km N of Lefroy, 41°2.03'S 146°57.77'E, 40 m, 26 Jan 1987, WFP JHW & GAC (1, AMS C202211); stn TA659, tributary of Second River 6 km along Doaks Rd, E of Lilydale, 41°15.38'S 147°16.55'E, 480 m, under rocks in flowing parts, 20 Feb 1989, WFP JHW & FEH (1, AMS C363907); stn JW30, tributary of St Patricks River near TA138, near Weavers Rd Nunamara, 41°23.3'S 147°19.7'E, underground seep near headwaters, 8 Feb 1988, JHW (1, AMS C202330); stn TA69, tributary of Arnon River on Kamona Valley Rd 200 m from Forester Rd turnoff, 41°5.683'S 147°38.383'E, on roots, dead leaves of swordgrass, 27 Jan 1987, WFP JHW & GAC (19, AMS C363890); stn TA72, tributary of Tomahawk River on Oxberry Rd 0.6 km W of junction with Base Rd, 41°1.5'S 147°42.4'E, 160 m, on weed, 27 Jan 1987, WFP JHW & GAC (9, AMS C363903).

Diagnosis. Dorsal carinae weak, often angulation only, at about sutural ¼ to ⅓, ventral carina moderately strong to weak, in inner ⅓ to middle of base; microsculpture of weak growth lines only. Radula with 5–8 cusps and abutting to slightly overlapping articulation.

Description. Shell (Figs. 9A,B,F; 10D,F–K,M) very small (up to 1.5 mm in max. diameter), orthostrophic, near planispiral, up to about 2.7 biangulated whorls. Protoconch (Fig. 9A,B,F) of about 1.0–1.2 whorls, sculptured with minute shallow, irregular pits, borders of pits irregular and wide, forming granulate texture. Protoconch followed by about ⅓ whorl of possible larval shell not clearly demarcated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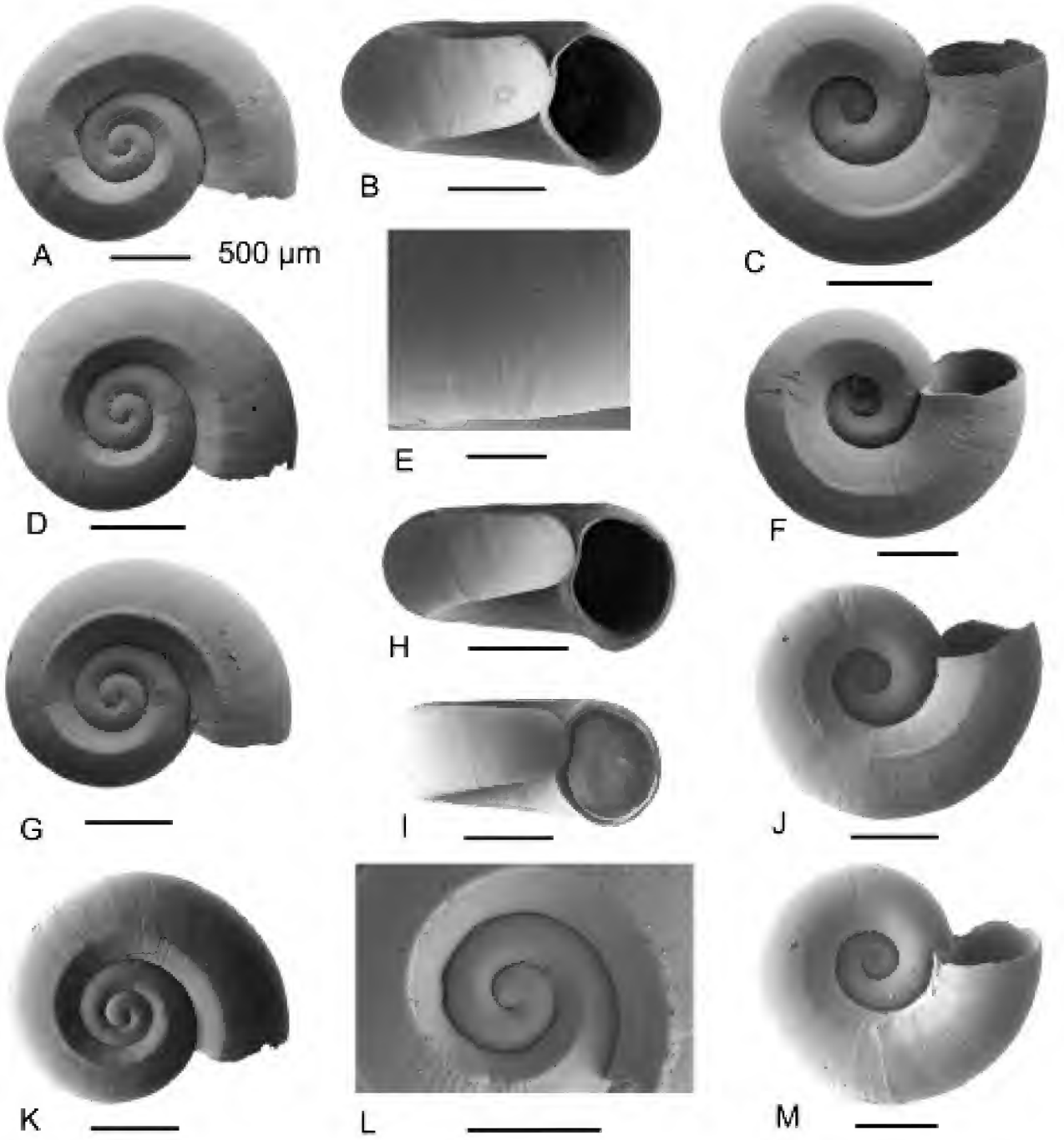

Figure 10. Shells of some Tasmanian members of the *Glacidorbis bicarinatus* species group. A–C,E,L: *Glacidorbis bicarinatus*; holotype (A) (AMS C351694); dorsal view. B,C,E,L: East of Preston, northern Tasmania (paratypes, AMS C202347); lateral and ventral view of two specimens; detail of first part of periphery of last whorl (E); detail of dorsal view (L). D,F–K,M: *Glacidorbis catomus* n.sp. D: holotype (AMS C350957); dorsal view. F–H: Monazite Ck, tributary of Surveyors Ck on Old Waterhouse Rd, NE Scottsdale, Tasmania (paratypes, TA68, AMS C202214). Ventral, dorsal and lateral views of three specimens. I–K,M: Hurst Ck, at Oakdene Rd, W of Scottsdale, Tasmania (paratypes, TA67, AMS C350050); lateral, dorsal and two ventral views of four specimens.

Figure 9 [facing page]. Protoconchs of *Glacidorbis bicarinatus* species group. A,B,F: *Glacidorbis catomus* n.sp. A,B: Hurst Ck, at Oakdene Rd, W of Scottsdale, Tasmania (paratype, AMS C350050); detail of microsculpture (B). F: Monazite Ck, tributary of Surveyors Ck on Old Waterhouse Rd, NE Scottsdale, Tasmania (paratype, AMS C202214); detail of microsculpture. C,D: *Glacidorbis bicarinatus* n.sp.; E of Preston, northern Tasmania (paratype, AMS C202347); detail of microsculpture (C). E: *Glacidorbis otwayensis* n.sp.; holotype (AMS C354937). G–I,L: *Glacidorbis decoratus* n.sp. G,I: tributary of Rapid River, S of Rapid River on Pipeline Rd, NW Tasmania (holotype, AMS C202367); detail of microsculpture (I). H,L: tributary of Mosquito Ck, on Corner Rd, NW Tasmania (AMS C350046); detail of microsculpture (H). J,K: *Glacidorbis rusticus* n.sp.; Squeaky Ck, Wilsons Promontory, Victoria (paratype, AMS C350047); detail of microsculpture (K). M–O: *Glacidorbis atrophus* n.sp. M: Wandle River on Murchison Hwy, N of Waratah, Tasmania (AMS C350045). N,O: tributary of Big Ck, off Tram Rd, S of Wynyard, Tasmania (paratype, AMS C202354); detail of microsculpture (O).

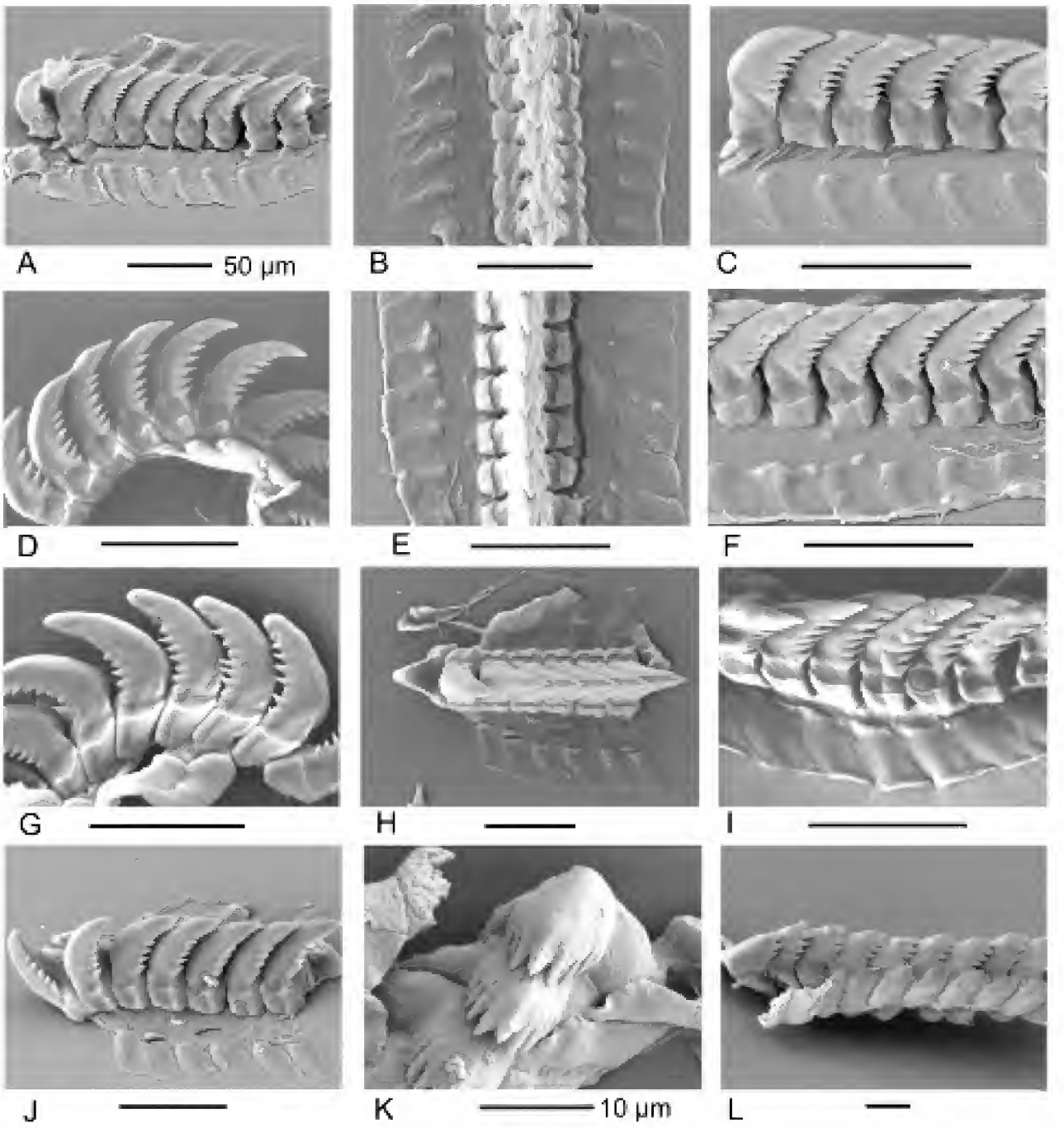

Figure 11. Radulae of *Glacidorbis* and *Benthodorbis*. A,B: *Glacidorbis bicarinatus* n.sp., E of Preston, northern Tasmania (paratype, AMS C202347); lateral and dorsal views. C,D: *Glacidorbis catomus* n.sp. C: Monazite Ck, tributary of Surveyors Ck on Old Waterhouse Rd, NE Scottsdale, Tasmania (paratype, TA68, AMS C202214); lateral view. D: Hurst Ck, at Oakdene Rd, W of Scottsdale, Tasmania (paratype, AMS C350050); lateral view. E,F: *Glacidorbis atrophus* n.sp.; tributary of Big Ck, off Tram Rd, S of Wynyard, NW, Tasmania (paratype, AMS C202354); dorsal and lateral views. G,I: *Glacidorbis rusticus* n.sp.; Squeaky Ck, Wilsons Promontory, Victoria (paratype, AMS C350047); lateral views. H,J: *Glacidorbis decoratus* n.sp.; tributary of Rapid River, S of Rapid River on Pipeline Rd, NW Tasmania (paratypes, AMS C202367); dorsal and lateral views. K,L: *Benthodorbis fultoni* n.sp.; Lake Sorell, Tasmania (paratype, MV F54907); dorsal and lateral views. Scale bars K and L 10 µm, remainder 50 µm.

from teleoconch. Teleoconch microsculpture of fine growth lines, first whorl fine axial growth lines, moderate to weak carina or angulation in dorsal sutural ¼ to ⅓ of whorl; base with moderate to weak carina or angulation in inner ⅓ to middle of whorl, weak to obsolete in some specimens (e.g., AMS C350050). Dorsal surface of whorls on sutural side of angulation strongly sloping into suture; periphery of last whorl evenly convex; ventral surface of last whorl convex (except angulation). Base with broad, shallow umbilicus; ratio of umbilical width to maximum diameter 0.59–0.67. Aperture subcircular (9 specimens examined using SEM from type locality, AMS C350050 and AMS C351675). Colour yellow-white to white, opaque to semi-translucent.

Dimensions. See Table 6.

Operculum (Fig. 7A,B) oval (width /length 0.77–0.80), flat, of c. 3.4 (c. 1.4 adult) whorls; width of last whorl/ length of operculum 0.36–0.37. Nucleus large, 0.37–0.41 length of operculum, spiral (about 2 whorls), eccentric. Inner surface with slightly raised spiral ridge surrounding nucleus. Exterior with numerous approximately spirally arranged pustules on last whorl (4 specimens examined from type locality (1) and AMS C350050 (3)).

Radula (Fig. 11C,D) of 18–20 rows (n = 6). Central teeth with 5–8 (usually 6–7) sharp, approximately equal-sized lateral cusps occupying about ⅔ to ¾ length of mesocone. Base wider than long, 0.35–0.47, 1.67–1.83 wider than width of mesocone, outer edges slightly concave to straight, dorsal basal thickening prominent, anterior articulatory thickening stronger than posterior, anterior articulation abuts to slightly overlapped by dorsal part of posterior articulatory area of tooth in front. Width of lateral elements about half their length, not tapering, straight to slightly curved, with posterior edge of inner ends weakly thickened; plates abutting to narrowly separated, anterior edges finely denticulate (9 radulae examined from type material [3] and AMS C350050 [3]).

Distribution (Fig. 8). North-flowing drainages, NE Tasmania.

Remarks. The material attributed to this species shows some variation between and within populations. A few lots (e.g., Fig. 10M) have specimens with a weak to subobsolete keel on the base, but the strength of the keel can vary within single samples (e.g., Fig. 10J,M).

Glacidorbis bicarinatus is larger and has stronger, raised basal and dorsal keels which are more centrally located on the whorls (cf. Fig. 10A with 10D,G,K) and has weak axial costae on the first whorl (Fig. 10L). The base of that species has the spiral cord located centrally and the inner whorl surface (sloping into the umbilical area) is flat, not weakly convex as it is in *G. catomus*.

Glacidorbis catomus is unusual in having the protoconch microsculpture with smaller pits with wider borders which form a granulate surface (Fig. 9B,F). The radula has 18–20 teeth in each row (compared with 21–22 in *G. bicarinatus*) and has 5–8 (usually 6–7) cusps on each tooth rather than 8–9.

Table 6. Shell measurements of *Glacidorbis catomus*.

dmin	dmax	mdht	mxht	aph	apw	whl
holotype (AMS C350957)						
1.31	1.59	0.44	0.81	0.72	0.53	2.52
paratypes (AMS C202214)						
1.38	1.57	0.52	0.87	0.73	0.62	2.55
1.51	1.73	0.57	0.87	0.82	0.59	2.65
1.29	1.57	0.44	0.83	0.67	0.60	2.40
additional specimens (AMS C350050)						
1.42	1.72	0.54	0.77	0.75	0.55	2.55
1.53	1.77	0.54	0.75	0.69	0.59	2.65
1.32	1.57	0.45	0.72	0.63	0.50	2.50
additional specimen (AMS C351675)						
1.33	1.62	0.49	0.71	0.69	0.54	2.50

Glacidorbis atrophus n.sp.

Derivation: *atrophus* (Latin, from the Greek *atrophos*)—emaciation, wasting away—refers to the weak spiral keels of this taxon.

Type material. HOLOTYPE, AMS C350958. PARATYPES (9): 2, AMS C202354; 6, AMS C354942; 1, QVM 9:1646.

Type locality. TA536, tributary of Big Ck, off Tram Rd, c. 8 km S of Wynyard, Tasmania, 41°3.28'S 145°41.65'E, 8 Feb 1989, WFP JHW & FEH, pH 6.07, cond. 0.14.

Additional material examined. TASMANIA: stn V1721, Dip River, below falls, 41°2.28'S 145°22.57'E, 28 Jan 1974, Univ. of Tas. (4, MV F60410); stn TA558, Dip Falls, Arthur River area, above falls, 41°2.22'S 145°22.72'E, 210 m, 10 Feb 1989, WFP & JHW (1, AMS C202364); stn C140T, Deep Gully Creek, tributary of Arthur River, at Murchison Hwy, 41°25.467'S 145°33.7'E, rocks and gravel in large stream, 23 Jan 1982, WFP WFPj & JH (3, AMS C363847); stn C139T, Wandle River on Murchison Hwy, N of Waratah, 41°21.81'S 145°34.83'E, 565 m, on weed, on and under stones, roots, 23 Jan 1982, WFP JH & WFPj (1, AMS C350045) (with *Tasmodorbis punctatus*); stn TA536, tributary of Big Ck, 41°3.267'S 145°41.65'E, 80 m, 8 Feb 1989, WFP JHW & FEH (14, AMS C364668); stn TA523, Wollastonite Ck, at Upper Natone Rd, 41°16.62'S 145°48.28'E, 400 m, on rocks and leaves, 6 Feb 1989, WFP JHW & FEH (1, AMS C202352).

Diagnosis. Shell with rather weak dorsal keel at about sutural ¼ and weak to subobsolete ventral keel. Distinct axial costae on spire of teleoconch. Radula with 5–7 cusps and abutting articulation.

Description. Shell (Figs. 9M–O, 12G–J) small (up to 1.8 mm in max. diameter), orthostrophic, near planispiral, up to about 2.7 whorls. Protoconch (Fig. 9M–O) of 1.0–1.2 whorls, sculptured with close, small, deep pits and a few irregular weak axial folds. Teleoconch sculpture of sharp axial riblets with interspaces approximately twice their width, becoming obsolete on last half whorl. Dorsal surface of whorls convex, with weak dorsal ridge forming on penultimate whorl, stronger on last whorl, at about inner ¼ of whorl; periphery of last whorl evenly convex; ventral surface of last whorl convex, with weak axial riblets and having weak to distinct angulation in centre. Base with

Table 7. Shell measurements of *Glacidorbis atrophus*.

dmin	dmax	mdht	mxht	aph	apw	whl
holotype						
1.32	1.64	0.49	0.70	0.62	0.56	2.45
paratypes (AMS C202354)						
1.33	1.62	0.45	0.76	0.68	0.54	2.40
1.41	1.69	0.48	0.79	0.71	0.60	2.65
figured specimen (AMS C350045)						
1.47	1.78	0.50	0.67	0.63	0.56	2.70

broad, shallow umbilicus; ratio of umbilical width to maximum diameter 0.62–0.65. Aperture subcircular (4 shells examined using SEM from type material [3] and AMS C350045). Colour pale yellow-brown to yellowish-white.

Dimensions. See Table 7.

Operculum (Fig. 7C,F) subcircular (width/length 0.75–0.84), flat, of c. 3 (1 adult) whorls, width of last whorl/length of operculum 0.42–0.46. Nucleus large, 0.38–0.40 length of operculum, spiral (of about 2 whorls), eccentric. Inner surface with slightly raised spiral ridge surrounding nucleus. Exterior with numerous irregular rows of spirally arranged pustules on last whorl (4 examined from type locality).

Radula (Fig. 11E,F) of 18–23 rows. Central teeth with 5–7 sharp, approximately equal-sized lateral cusps occupying about ⅔ length of mesocone. Base 0.18–0.19 wider than long, about 0.44–0.45 wider than width of mesocone, outer edges almost straight to slightly convex, dorsal basal thickening strong, anterior articulatory thickening markedly stronger than posterior, anterior articulation abuts tooth in front. Lateral elements not tapering, moderately curved, width approximately half length, with weakly thickened inner ends; teeth abutting (2 radulae examined from type locality).

Distribution (Fig. 8). North east Tasmania in north flowing drainages from Dip River in the north west to Little Clayton's Rivulet in the mid north coast.

Remarks. This taxon differs from *G. bicarinatus* in having weaker dorsal and ventral ridges placed close to the suture (not in or near the middle of the whorls) and more distinct axial sculpture. *Glacidorbis bicarinatus* in the mid north coast appears to be separated from *G. atrophus* which is further to the west. *Glacidorbis catomus* in the NE of Tasmania has a similar configuration of the keels but lacks the distinct axial costae on the spire.

Glacidorbis decoratus n.sp.

Derivation: *decoratus* (Latin)—ornament. Refers to the ornamented shell of this species.

Type material. HOLOTYPE, AMS C350956. PARATYPES (7): 2, AMS C202367; 4, AMS C355558; 1, QVM 9:1645.

Type locality. Stn TA579, tributary of Rapid River, 3.4 km S of Rapid River on Pipeline Rd, Tasmania, 41°17.5'S 145°18.417'E, on vegetation, 12 Feb 1989, WFP JHW & FEH, pH 6.04.

Additional material examined. TASMANIA: stn TA562, tributary of Fixters Ck at N end of Brittons Swamp, 40°54.783'S 144°57.85'E, 60 m, under and on wood, roots and leaves, 11 Feb 1989, WFP JHW & FEH (2, AMS C363891); stn TA550A, tributary of Mill Ck, tributary of Duck River, 40°59.433'S 145°0.417'E, 40 m, on treefern roots and under wood, 10 Feb 1989, WFP & JHW (1, AMS C363895); stn TA549, Blizzards Ck on Youngs Rd, S of Irishtown, in seeping gully, 40°56.55'S 145°8.983'E, 180 m, wood, leaves and stones, 9 Feb 1989, WFP JHW & FEH (9, AMS C363909); stn TA571, tributary of Mosquito Ck, just before Pipeline Rd on Corner Rd, 40°55.383'S 145°19.483'E, 100 m, on leaves, roots and pieces of wood, 12 Feb 1989, WFP JHW & FEH (6, AMS C350046; many, AMS C353991); stn TA554, Chester Ck, tributary of Arthur River, 41°5.717'S 144°58.917'E, 50 m, under leaves, stones, wood on sides of creek, or on surface if sheltered, 10 Feb 1989, WFP & JHW (3, AMS C363896); stn TA96/16, small tributary on N side of Middleton Creek on Tarkin Rd, 0.5 km from turnoff to Corinna, 41°37.9'S 145°5.52'E, under stones, wood and on roots, 26 Dec 1996, WFP (3, AMS C204079); stn TA585, 16.4 km SW of Rapid River, on Pipeline Rd, 41°23.15'S 145°13.55'E, 380 m, stones, moss and wood, 12 Feb 1989, WFP JHW & FEH (1, AMS C363898); stn TA581, tributary of Little Donaldson River, 11 km SW of Rapid River on Pipeline Rd, 41°20.5'S 145°15.783'E, 460 m, on wood, stones, vegetation and on surfaces, 12 Feb 1989, WFP JHW & FEH (2, AMS C363893); stn C144T, Thirteen Mile Ck tributary of Heazlewood River, junction of Mt Cleveland and Corinna Rds, 41°28.53'S 145°20.45'E, 290 m, weed washings, 24 Jan 1982, WFP JH & WFPj (1, AMS C202189); stn TA592, 28.0 km from Murchison Hwy, on Pieman Rd, 1.9 km W of Wilson River, 41°43.933'S 145°20.783'E, 200 m, on stones in fast flowing areas, 13 Feb 1989, WFP JHW & FEH (1, AMS C363897).

Diagnosis. Shell with strong, typically raised dorsal and ventral keels and distinct, sharp riblets over most of the shell surface. Radula with 4–6 cusps and abutting articulation.

Description. Shell (Figs. 9G–I, 12A–F) small (up to 2.0 mm in max. diameter), orthostrophic, near planispiral, of up to about 2.7 whorls. Protoconch (Fig. 9G–I) of 1.0–1.1 whorls, sculptured with closely spaced pits. Teleoconch sculpture of sharp, distinct axial ribs with interspaces about twice to three times the width of the ribs. Dorsal surface of whorls strongly angled by prominent ridge in inner third of whorl, inner side of whorl steeply inclined to suture. Base with axial sculpture similar to that on dorsal surface; and mid-ventral ridge, typically bearing two spiral ribs; periphery of last whorl evenly convex. Base with broad, shallow umbilicus; ratio of umbilical width to maximum diameter 0.65–0.67. Aperture pyriform (7 specimens examined using SEM from type locality and AMS C350046). Colour yellow-brown to yellowish-white.

Dimensions. See Table 8.

Operculum (Fig. 7D,E) oval (width/length 0.72–0.83), flat, of c. 3 (1 adult) whorls, width of last whorl/length of operculum 0.43–0.49. Nucleus large, 0.30–0.39 length of

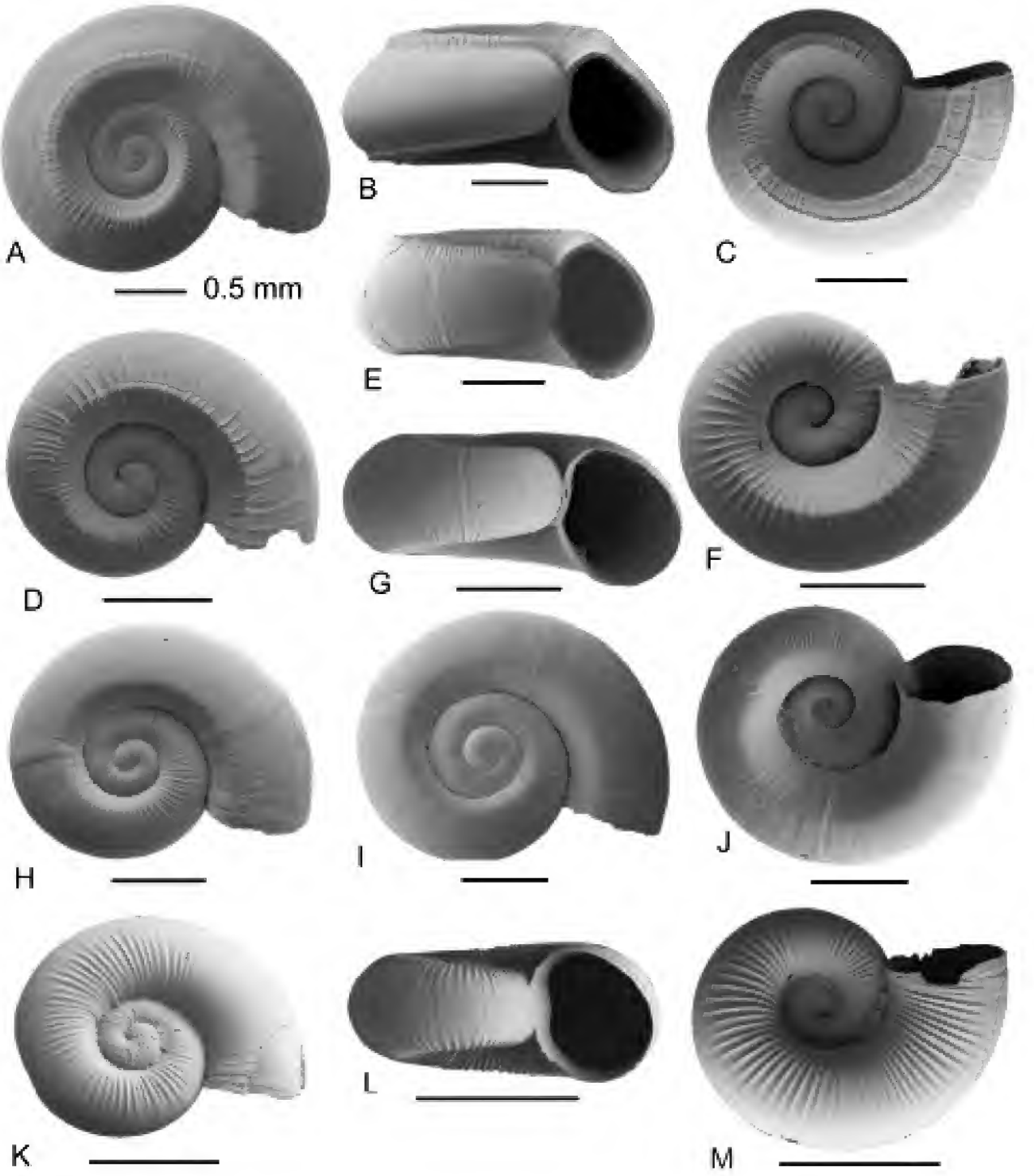

Figure 12. Shells of some Tasmanian members of the *Glacidorbis bicarinatus* species group and *G. costatus* n.sp. A–F: *Glacidorbis decoratus* n.sp. A: holotype (AMS C350956); dorsal view. B–C: tributary of Rapid River, S of Rapid River on Pipeline Rd, NW Tasmania (paratypes, AMS C202367); lateral and ventral views of two specimens. D–F: tributary of Mosquito Ck, on Corner Rd, NW Tasmania (AMS C350046); dorsal, lateral and ventral views of three specimens. G–J: *Glacidorbis atrophus* n.sp. G,J: tributary of Big Ck, off Tram Rd, S of Wynyard, NW Tasmania (paratypes, AMS C202354); lateral and ventral views of two specimens. H: holotype (AMS C350958); dorsal view. I: Wandle River on Murchison Hwy, N of Waratah, Tasmania (AMS C350045); dorsal view. K–M: *Glacidorbis costatus* n.sp. K: holotype (AMS C351684); dorsal view. L,M: Pulbeena Swamp, NW Tasmania (paratypes, AMS C201807); lateral and ventral views.

Table 8. Shell measurements of *Glacidorbis atrophus*.

dmin	dmax	mdht	mxht	aph	apw	whl
holotype						
1.63	1.99	0.73	0.98	0.90	0.64	2.60
paratypes (AMS C202367)						
1.57	1.99	0.66	1.02	0.90	0.64	2.55
1.34	1.62	0.54	0.94	0.90	0.58	2.30
figured specimens (AMS C350046)						
1.00	1.21	0.36	0.69	0.67	0.41	2.15
0.82	1.06	0.29	0.64	0.57	0.33	1.95
1.49	1.82	0.59	0.88	0.81	0.57	2.50
additional specimens (AMS C350046)						
1.59	1.96	0.62	0.88	0.81	0.60	2.65
1.36	1.57	0.56	0.82	0.73	0.53	2.50
1.46	1.78	0.58	0.81	0.71	0.56	2.65

operculum, spiral (of about 2 whorls), markedly eccentric. Inner surface with slightly raised spiral ridge surrounding nucleus. Exterior with many rather irregular, approximately spirally arranged pustules on last whorl (5 specimens examined using SEM from type locality [1] and AMS C350046 [4]).

Radula (Fig. 11H,J) of 21–23 rows. Central teeth with 4–6 (usually 5) sharp, approximately equal-sized lateral cusps occupying just over half to ⅔ length of mesocone. Base about twice as wide as long, about 1.54–1.59 wider than mesocone; outer edges slightly concave, dorsal basal thickening strong, narrow, anterior articulatory thickening much stronger than posterior, anterior articulation abuts tooth in front. Width of lateral elements about half length, slightly curved, abutting; weakly thickened towards inner ends.

Distribution (Fig. 8). North west Tasmania mainly in western drainages and northern drainages west of Port Latta.

Remarks. This taxon differs from *G. atrophus* in having much stronger, sharper dorsal and ventral ridges that are typically raised, and stronger axial ribs that extend over the whole dorsal and ventral shell surface. It differs from *G. bicarinatus* and *G. rusticus* in having axial ribs over the whole shell surface, in the dorsal keel usually being more pronounced. Some immature specimens of *G. bicarinatus* superficially resemble this species.

Glacidorbis rusticus n.sp.

Derivation: *rusticus* (Latin)—of the country side.

Type material. HOLOTYPE, AMS C351663. PARATYPES: 3, AMS C350047; many, AMS C353953; 3, MV F82290.

Type locality. EV195, Squeaky Ck at footbridge on track near car park, Wilsons Promontory, Victoria, 39°01.45'S 146°18.67'E, on weeds, 13 Feb 1990, WFP & JHW, pH 5.64, cond. 0.39.

Additional material examined. VICTORIA: Wilsons Promontory: stn EV153, Golden Ck, W of Corner Inlet, 38°44.75'S 146°10.52'E, 20 m, 11 Feb 1990, WFP GAC RdK & DLB (1, AMS C354055); stn EV172, Tin Mine Ck, at Tin Mine Cove, 38°48.66'S 146°25.53'E, 20 m, in water weeds, 14 Feb 1990, WFP & GAC (8, AMS C365981); stn EV27, creek at southern end of Johnny Souey Cave, near road track close to beach, 38°53.67'S 146°28.8'E, 20 m, in weed, 12 Dec 1988, JHW & GAC (1, AMS C365987); stn EV135, swampy area 3.1 km N of Darby Saddle, 38°59.05'S 146°17.15'E, 20 m, in short turf-like sedge, 8 Feb 1990, JHW & ACM (9, AMS C365984); stn EV145, Upper Whisky Ck, minor E tributary, 39°0.1'S 146°18'E, 120 m, leaf litter, 8 Feb 1990, WFP & DLB (5, AMS C354035); stn EV146, Whisky Ck tributary, on E of main creek, second from top, 39°0.167'S 146°17.95'E, 140 m, leaf litter, 8 Feb 1990, WFP & DLB (1, AMS C365976); stn EV36B, Whiskey Ck, seepage, near road, 39°0.383'S 146°17.6'E, 40 m, in leaf litter and weed, 13 Dec 1988, JHW & GAC (many, AMS C365986); stn EV132, Lilly Pilly Ck tributary, 39°0.433'S 146°20'E, 100 m, leaf litter in seepage, 8 Feb 1990, JHW & ACM (4, AMS C354050); stn EV171, Tidal River tributary, E of Lilly Pilly Gully, 39°0.467'S 146°20.617'E, 20 m, weeds, roots, leaves and debris, 13 Feb 1990, WFP & ACM (7, AMS C365978); stn EV188, Squeaky Ck tributary, c. 150 m in (N) from road and c. 15–20 m above swamp, 39°0.55'S 146°18.55'E, 60 m, on leaf litter and debris, 13 Feb 1990, WFP & JHW (1, AMS C353952); stn EV187A, Squeaky Beach Ck c. 60 m from road upstream on N side, 39°0.7'S 146°18.35'E, 20 m, on leaves, 13 Feb 1990, WFP & JHW (many, AMS C353955); stn EV37A, Squeaky Ck (top of) at road, 39°0.7'S 146°18.367'E, 50 m, in leaves etc., in small, seepy, swampy area, 13 Dec 1988, JHW & GAC (many, AMS C354041); stn EV150, same loc., leaf litter and mud, 8 Feb 1990, WFP & DLB (many, AMS C365989); stn EV165, Blackfish Ck, in Sealers Swamp, 39°0.917'S 146°25.15'E, 20 m, ferntree roots out of main flow and in leaves, 10 Feb 1990, WFP & RdK (1, AMS C353960); stn EV138, creek in Sealers Swamp, 39°1.33'S 146°25.55'E, in water weed, 10 Feb 1990, JHW & ACM (2, AMS C353954); stn EV141, Titania Ck tributary, 1 km W of Windy Saddle, on walking track, 39°1.483'S 146°21.95'E, 300 m, leaf litter, 10 Feb 1990, JHW & ACM (4, AMS C354052); stn EV187B, Squeaky Beach Ck, uphill side of road, 39°1.49'S 146°18.67'E, 20 m, small, swampy stream, 13 Feb 1990, WFP & JHW (11, AMS C365982); stn EV170, Titania Ck tributary (no. 3), 1.25 km E of car park, 39°1.5'S 146°21.817'E, 260 m, in leaves in stream, in moss also, 10 Feb 1990, WFP & RdK (3, AMS C353951); stn EV169, Titania Ck tributary, 700 m W of Windy Saddle, 39°1.55'S 146°22.117'E, 320 m, in leaves in stream, 10 Feb 1990, WFP & RdK (5, AMS C353956); stn EV204, Growler Ck (top of), 0.5 km from gate, 39°1.733'S 146°21.15'E, 260 m, leaf litter, 13 Feb 1990, GAC & DLB (2, AMS C354042); stn EV119, Growler Ck tributary, 1 km from gate (E side of Mt Oberon), 39°1.85'S 146°21.183'E, 160 m, in water weeds, 7 Feb 1990, GAC RdK & ACM (1, AMS C365983); stn EV35, Growler Ck tributary, draining Mt Oberon, 39°2.45'S 146°21.217'E, 80 m, in fern roots, leaves, etc., along edges of creek, 13 Dec 1988, JHW & GAC (1, AMS C365985); stn EV155, Little Waterloo Bay camping area, 39°3.367'S 146°25.75'E, 40 m, leaves in small seep at side, 12 Feb 1990, WFP & DLB (1, AMS C353958); stn EV116, Lighthouse Track, 39°3.5'S 146°22'E, 20 m, seepage by road on side of track, in waterweed, 7 Feb 1990, GAC RdK & ACM (many, AMS C354038); stn EV25, Growler Ck, 39°3.75'S 146°22.417'E, 20 m, in weed, 11 Dec 1988, JHW & GAC (1, AMS C354039); stn EV115, Growler Ck, at road bridge, 39°3.77'S 146°22.43'E, 20 m, roots and debris at side, on weeds, 7 Feb 1990, GAC & RdK, ACM (9, AMS C365979); stn EV130, Frasers Ck, near campsite, 39°3.85'S 146°20.383'E, 20 m, on weed and leaves, mostly leaves, 7 Feb 1990, WFP & JHW (7, AMS C354047); stn EV158, Freshwater Ck, second tributary from Waterloo Bay on S side, 39°3.95'S 146°24.75'E, 20 m, on weeds, 12 Feb 1990, WFP & DLB (1, AMS C353959); stn EV183, Freshwater Ck, 3rd tributary from Waterloo Bay, 39°4.51'S 146°24.52'E, 40 m, leaf litter, 12 Feb 1990, WFP & DLB (several, AMS C354045); stn EV184, upper tributary of Growler Ck, 39°4.53'S 146°24.25'E, 60 m, mud and leaf litter, 12 Feb 1990, WFP & DLB (4, AMS C365980); stn EV159, Freshwater Ck, 1.5 km from Waterloo Bay Beach, 39°4.6'S 146°24.7'E, on vegetation, 12 Feb 1990, WFP & DLB (many, AMS C365977); stn EV129, W tributary of Roaring Meg Ck, near camping area, 39°6.35'S 146°23.017'E, 200 m, on moss and leaf litter along edges, 7 Feb 1990, WFP JHW & DLB (6, AMS C353957); stn EV202, Roaring Meg Ck tributary, second creek on Lighthouse track from Roaring Meg campsite, 39°6.517'S 146°23.533'E, 160 m, leaf litter, tree fern mat, 13 Feb 1990, GAC & DLB (1, AMS C354053); stn EV125, First Bridge Ck,

S end of Wilsons Promontory, 39°6.733'S 146°24.183'E, 200 m, leaf litter, overhanging vegetation, mud, etc., 7 Feb 1990, WFP JHW & DLB (many, AMS C354040); stn EV22, same loc., in moss at waters edge, 11 Dec 1988, JHW & GAC (19, AMS C365975).

Material tentatively assigned to this taxon. VICTORIA: Werribee River, picnic spot, 11.5 km NNW of Ballan, 37°29'S 144°10'E, 11 Oct 1983, A.J. Boulton (5 partially decalcified specimens recorded as *G. hedleyi* by Boulton & Smith, 1985 but are similar to the Wilsons Promontory material, MV F52153); Diamond Ck, tributary of Bunyip River, at Mortimore Reserve, Victoria, 37°59.08'S 145°35.52'E, 170 m, in litter and fern roots, 4 Feb 1994, G.R. Macaulay (1, AMS C302557); stn T20 no. 1, Thomson–Aberfeldy junction, Fingerboard spur track, Victoria, 37°48'S 147°19'E, 26 Nov 1976, MV Survey Dept. (1 decalcified specimen identified by B.J. Smith as *G. hedleyi* but has a deeper body—the presence of keels could not be ascertained with certainty, MV F54916).

Diagnosis. Shell surface with weak growth lines and strong keel dorsally and ventrally. Radula with 5–7 cusps and non-overlapping articulation.

Description. Shell (Figs. 9J,K; 13A–F) small (up to 2.1 mm in max. diameter), orthostrophic, near planispiral, of about 2.7 whorls. Protoconch (Fig. 9J,K) of 1.1 whorls, sculptured with numerous, close pits. Protoconch followed by about ⅓ whorl of possible larval shell not clearly demarcated from teleoconch. Teleoconch sculpture of fine growth lines and strong keel in dorsal ⅓ and strong to moderate keel mid ventrally. Dorsal surface of whorls strongly angulated by keel, steeply inclined to suture; some specimens (including holotype) with a groove between keel and suture; periphery of last whorl evenly convex; ventral surface of last whorl angled by keel, otherwise convex. Base with broad, shallow umbilicus; ratio of umbilical width to maximum diameter 0.70–0.75. Aperture subcircular (examined using SEM from type locality). Colour pale yellow-brown to yellowish-white; sometimes stained red-brown.

Dimensions. See Table 9.

Operculum (Fig. 7G,H) oval (width/length 0.77–0.84), flat, of c. 3.5 whorls (c. 1.5 adult), width of last whorl/length of operculum 0.37–0.43. Nucleus large, 0.41–0.43 length of operculum, spiral (of about 2 whorls), eccentric. Inner surface with raised spiral ridge surrounding nucleus. Exterior with many irregular rows of approximately spirally arranged pustules on last whorl (examined from 4 specimens from type locality).

Radula (Fig. 11G,I) of about 23 rows. Central teeth with 5–7 (usually 6) sharp, approximately equal-sized lateral cusps occupying about ⅔ to ¾ of length of mesocone. Base about twice as wide as long, about 1.70–1.73 wider than width of mesocone, outer edges nearly straight, dorsal basal thickening well developed, anterior articulatory thickening stronger than posterior, anterior articulation abuts tooth in front but just inside this posterior base of tooth overlaps anterior edge of tooth behind. Width of lateral elements about 1.25 to twice length, straight laterally, abutting, with weakly thickened inner ends, anterior margin finely denticulate.

Several specimens were examined alive from the type locality and the following notes on the living animal made:

The head-foot of the living animal is similar to that of *G. hedleyi*, with long slender tentacles held almost at right angles to the head. The eyes are in the middle of the bases of the tentacles. The foot is narrowly expanded laterally anteriorly, and the anterior margin has a shallow indentation while posteriorly it is bifid. A short "siphon" projects from the posterior corner of the aperture. The head is broad with a short snout. The head and foot are grey laterally and dorsally, the siphon pale grey. The tentacles are unpigmented except for their grey edges. Specimens seen alive from Tin Mine Bay are unpigmented. Three adults were examined for brooded embryos but none were found.

Distribution (Fig. 5). Wilsons Promontory, Victoria and a few localities in eastern Victoria.

Remarks. This species is common and widespread on Wilsons Promontory. Only one intact shell from one locality (Diamond Creek) outside Wilsons Promontory is available, probably in part because of a lack of collecting. An attempt by the senior author to find *Glacidorbis* in Diamond Creek in 1998 failed. Two other records outside Wilsons Promontory are based on decalcified material so are only tentatively assigned to this taxon.

This taxon is similar to *G. bicarinatus* in the disposition and strength of the dorsal and ventral keels, differing only in a few characters. The shell is transparent pale yellowish in the Wilsons Promontory material, while it is white and opaque, or at most only slightly semi-translucent, in *G. bicarinatus*. In addition, spiral microsculpture is absent and the axial costae are not developed on the spire as they are in *G. bicarinatus*. The radula, while generally similar, has a narrower base than that of *G. bicarinatus*, the mesocone extending closer to the outer edges, and the articulation is slightly different. In *G. bicarinatus*, the base adjacent to the posterior articulation is concave and abuts the tooth in front (Fig. 11A). In *G. rusticus*, this part of the base is extended as a weak angulation (Fig. 11G,I) and overlaps the anterior part of the base of the tooth behind it. The radula also differs in having a smaller number of cusps (5–7 compared with 8–9). *Glacidorbis atrophus* differs in having weaker carinae and axial costae whereas *G. decoratus* differs in having even more pronounced carinae and axial costae over the whole surface. *Glacidorbis catomus*, like *G. rusticus*, lacks axial costae but has less pronounced carinae that are closer to the suture and often just angulations.

Table 9. Shell measurements of *Glacidorbis rusticus*.

dmin	dmax	mdht	mxht	aph	apw	whl
holotype						
1.47	1.79	0.61	0.94	0.86	0.66	2.70
paratypes (AMS C350047)						
1.46	1.74	0.52	0.89	0.84	0.66	2.55
1.74	2.06	0.70	1.06	0.97	0.71	2.60
1.59	1.86	0.60	0.92	0.87	0.64	2.65
figured specimen (AMS C302557)						
1.38	1.63	0.47	0.81	0.80	0.66	2.60

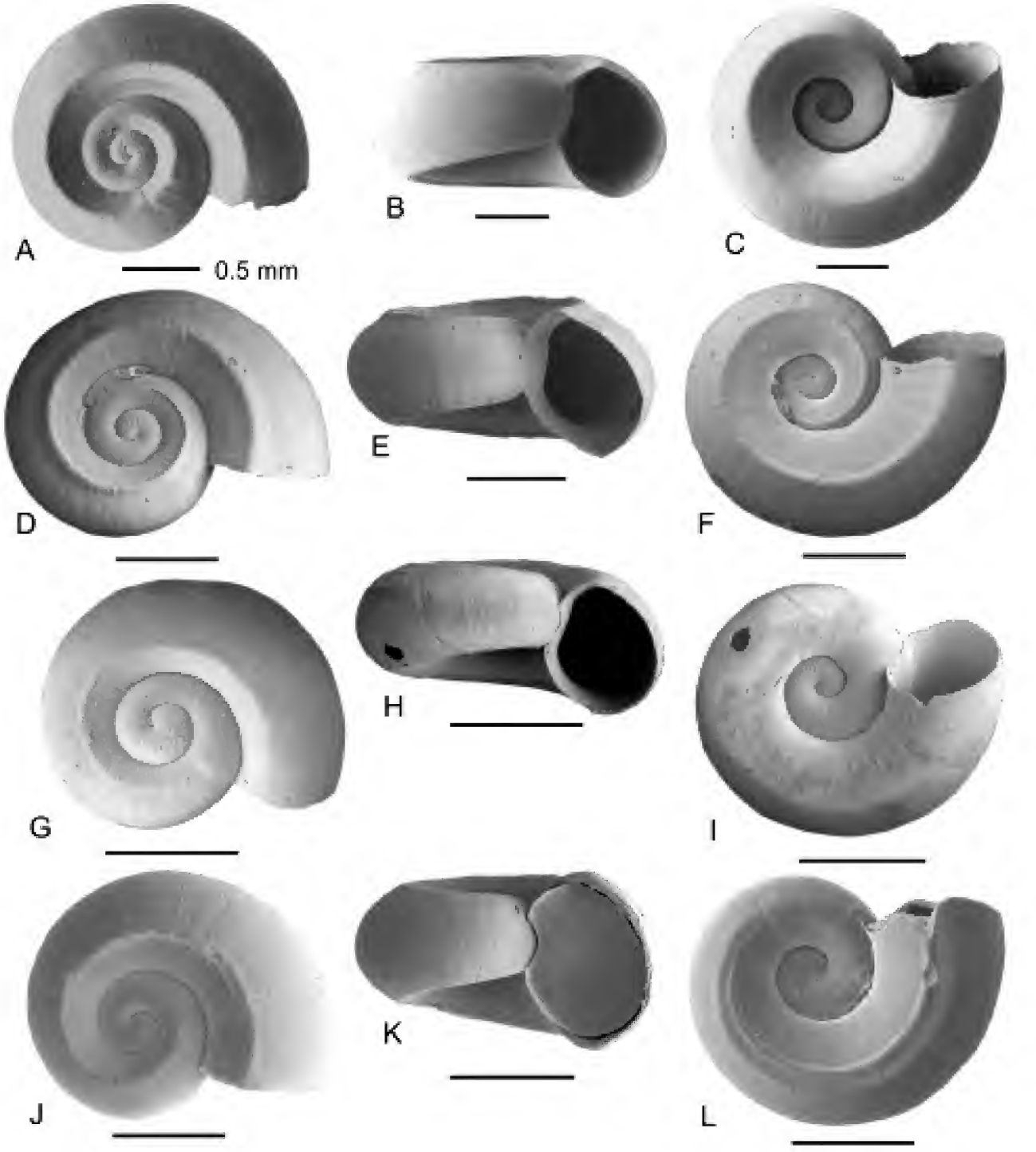

Figure 13. Shells of the Victorian members of the *Glacidorbis bicarinatus* species group and *G. isolatus* n.sp. A–F: *Glacidorbis rusticus* n.sp. Squeaky Ck, Wilsons Promontory, Victoria. A: holotype (AMS C351663), dorsal view. B,C: lateral and ventral views of two paratypes (AMS C350047). D–F: Diamond Ck, tributary of Bunyip River, at Mortimore Reserve, Victoria (AMS C302557); dorsal, lateral and ventral views. G–I: *Glacidorbis otwayensis* n.sp.; holotype (AMS C354937); dorsal, lateral and ventral views. J–L: *Glacidorbis isolatus* n.sp.; Swamp SE of Munro Hut, Kerripit River tributary, Barrington Tops SF, NSW. J: holotype (AMS C351676); dorsal view. K,L: paratypes, lateral and ventral views (AMS C201633).

Glacidorbis otwayensis n.sp.

Derivation. Named after the Otway Ranges where this taxon is found.

Type material. HOLOTYPE, AMS C354937.

Type locality. Stn FA194, small creek at road bridge 3 km S of Nirranda East on road to Curdie Vale, Otway Ranges, Victoria, 38°33.16'S 142°50.45'E, in waterweed, 22 Apr 1988, F.W. Aslin.

Material examined. VICTORIA: Stn V17, 2.3 km from Erskine Rd turnoff (Todds Corner), 38°31.917'S 143°50.817'E, leaves, roots, rocks, mud, 15 Jul 1991, WFP (1, AMS C353940); stn V20, 1.4 km SW from Kennett Rd, 2.3 km NE from Grey River Rd, 38°36.683'S 143°46.983'E, on leaves, moss etc., 15 Jul 1991, WFP (1, AMS C353939).

Diagnosis. Shell minute (about 1 mm in max. diameter), with weak dorsal keel or subangulation, and weak ventral subangulation and relatively large protoconch.

Description. Shell (Figs. 9E, 13G–I) minute (0.9 mm in max. diameter), orthostrophic, near planispiral, of about 2.1 whorls. Protoconch (Fig. 9E) relatively large, of about 1.3 whorls, sculptured with numerous, close pits over all but last quarter whorl. Protoconch followed by about ¼ whorl of possible larval shell not clearly demarcated from teleoconch. Teleoconch sculpture of fine growth lines and weak keel in dorsal ⅓ and subangulation mid ventrally. Dorsal surface of whorls weakly angulated by keel, steeply inclined to suture; periphery of last whorl evenly convex; mid-ventral surface of last whorl subangled, otherwise convex. Base with broad, shallow umbilicus; ratio of umbilical width to maximum diameter 0.70. Aperture subcircular (holotype examined using SEM). Colour semi-transparent yellowish-white.

Dimensions. See Table 10.

Operculum paucispiral, with eccentric nucleus. Radula not examined.

Distribution (Fig. 5). Otway Ranges.

Remarks. Only three lots, each with a single specimen that can be assigned to this taxon, which appears to be restricted to the Otway Ranges. This small species is treated as a member of the *G. bicarinatus* species group because of the shell possessing a strongly pitted protoconch and dorsal and ventral angulations. It has a weak angulation in the sutural third of the dorsal surface and a trace of a ventral angulation, but is otherwise smooth. The shell of this species is also similar to that of *G. hedleyi*, especially the forms with a weak dorsal angulation. It differs from that species in its smaller size, weak basal subangulation, and pitted protoconch microsculpture.

The shell of this taxon differs from all of the other members of the *G. bicarinatus* species group in having weaker dorsal and ventral angulations and in its smaller size. The protoconch is relatively larger than in the other species similar to *G. bicarinatus*. In *G. otwayensis*, the width of the protoconch/shell maximum diameter is 0.27 compared with 0.23–0.14 in the other species. It also has fewer whorls, 2.1 compared with about 2.5–2.7 in fully mature specimens of *G. bicarinatus* and similar species.

This taxon is unusual in having (in the one specimen examined using SEM) the last quarter whorl of the initial part of the protoconch smooth, in contrast to strong pitting on most of the protoconch. The coiling is slightly asymmetrical in the holotype but this is not a feature of the other two specimens. The additional specimens also differ in having the weak dorsal keel reduced to an angulation.

Table 10. Shell measurements of the holotype of *Glacidorbis otwayensis*.

	dmin	dmax	mdht	mxht	aph	apw	whl
holotype	0.71	0.89	0.26	0.44	0.4	0.33	2.5

Glacidorbis costatus n.sp.

Derivation: *costatus* (Latin)—ribbed.

Type material. HOLOTYPE, AMS C351684. PARATYPES (additional paratypes listed below): 2, AMS C201807; 10, AMS C353964.

Type locality. Stn TA717, Pulbeena Swamp, S of Smithton, NW Tasmania, 40°52.62'S 145°8.451'E, from banks of old quarry at edge of water, 8 Feb 1995, SAC & ACM.

Additional paratypes. 7 PARATYPES, Pulbeena Swamp, S of Smithton, NW Tasmania, 40°52.62'S 145°8.451'E, 140 cm from surface, in fine peaty marl, coll. N. Porch (QVM 15188); 20 PARATYPES, same loc. and collector, 85 cm from surface, coarse peaty marl (AMS C202369); many PARATYPES, same loc. and collector, 15–20 cm from surface, coarse peaty marl (AMS C202349; 3, TM E23420).

Diagnosis. Shell with well-developed axial costae over whole surface, and weak spiral cords, but lacks spiral keels.

Description. Shell (Figs. 2L, 12K–M) very small (up to 1.1 mm in max. diameter), orthostrophic, near planispiral, of about 2.2 whorls. Protoconch (Fig. 2L) of about 1.1 whorls, sculptured with relatively large pits. Teleoconch sculpture of numerous sharp, strong axial ribs with interspaces about twice their width. About 3 widely spaced weak spiral ribs dorsally, and many fine spiral threads; ventral surface with weak spiral threads; spirals lacking on periphery. Dorsal surface, periphery and base evenly convex. Base with broad, shallow umbilicus; ratio of umbilical width to maximum diameter about 0.54. Aperture subcircular (3 specimens examined using SEM from type locality). Colour white.

Dimensions. See Table 11.

Operculum and radula unknown.

Table 11. Shell measurements of the types of *Glacidorbis costatus*.

dmin	dmax	mdht	mxht	aph	apw	whl
holotype						
0.90	1.11	0.31	0.49	0.46	0.40	2.20
paratypes (AMS C201807)						
0.82	1.00	0.27	0.43	0.44	0.37	2.10
0.79	0.96	0.29	0.44	0.42	0.36	2.20

Distribution (Fig. 8). Pulbeena Swamp, north west Tasmania (Pleistocene-Holocene).

Remarks. This species is known only as a fossil from Pulbeena Swamp in north western Tasmania. This location is a large (c. 1.7 km^2) swamp at about 30 m altitude. It consists of late Quaternary peats and shelly marls that were exposed in a quarry (now disused). A section exposed during the late 1970's was described stratigraphically and its pollen (Colhoun *et al*., 1982) and ostracod (De Deckker, 1982) sequences analysed.

Glacidorbis costatus occurs through most of the sequence, along with other molluscs, mainly two species of Austropyrgus, which are much more abundant. Because *G. costatus* has not been collected alive, despite rather intensive collecting in the general area, it is assumed to be extinct. The extinction probably occurred when the wet land was drained in the early part of this century (De Deckker, 1982), because *Glacidorbis* is found right through the sequence.

Glacidorbis isolatus n.sp.

Derivation: *isolatus* ("New Latin")—detached, separate.

Type material. HOLOTYPE, AMS C351676. PARATYPES: 2, AMS C201633; 6 dry and many wet, AMS C353962.

Type locality. Stn BT985, swamp SE of Munro Hut, Kerripit River tributary, Barrington Tops SF, NSW, 32°3.7'S 151°34.7'E, near creek, 27 Mar 1985, WFP.

Additional material examined. NEW SOUTH WALES: Stn 1003, NE of Armidale, 23 km E of Guyra, Aberfoyle River, backwaters of stream, 30°12.78'S 151°52.72'E, 23 Nov 1972, G. Witten (3, AMS C364698); stn BT2185, Kholwha Ck, 2 km SE of Mt Polblue on Polblue Trail, near Little Murray picnic area, Barrington Tops, 31°59.04'S 151°27.58'E, 1480 m, small weedy stream, 28 Mar 1985, WFP (9, AMS C306333); stn BT285, 4 km due E of Gloucester Tops Trig Station, 32°3.3'S 151°36.3'E, small stream, 27 Mar 1985, WFP (16, AMS C365963); stn BT004, Barrington Tops, Munroe Hut, 32°3.7'S 151°34.6'E, 21 Dec 1997, WFP (1, AMS C353963).

Diagnosis. Shell bicarinate due to strong dorsal and ventral keels, otherwise smooth except for weak axial growth lines. Protoconch microsculpture of weak pustules.

Description. Shell (Figs. 2F, 13J–L) very small (up to about 1.3 mm in max. diameter), orthostrophic, near planispiral, of about 2 whorls. Protoconch (Fig. 2F) of 1.1 whorls, sculptured with fine pustules. Protoconch followed by about ½ whorl of probable larval shell with fine axial striae and clearly demarcated from teleoconch. Teleoconch sculpture of fine growth lines; dorsally angulated with strong keel in dorsal inner ⅓ which becomes weakly bifid on last whorl. Angulated mid ventrally by strong double keel. Dorsal surface inside keel strongly inclined towards suture; periphery of last whorl evenly convex. Base with broad, shallow umbilicus; ratio of umbilical width to maximum diameter 0.65. Aperture oval, angled above and below (types examined using SEM). Colour yellowish-white.

Dimensions. See Table 12.

Operculum. Not examined in detail. Oval, with eccentric nucleus and exterior granules.

Radula. Not examined.

Table 12. Shell measurements of the types of *Glacidorbis isolatus*.

dmin	dmax	mdht	mxht	aph	apw	whl
holotype						
1.10	1.34	0.44	0.74	0.60	0.51	1.95
paratypes (AMS C201633)						
0.68	1.23	0.35	0.69	0.70	0.51	1.90
1.02	1.27	0.40	0.68	0.59	0.49	2.05

Distribution (Fig. 5). Barrington Tops and Gloucester Tops, NSW where it is broadly sympatric with *G. hedleyi*, although so far the two species have not been found living together. Also known from one locality in the New England area.

Remarks. This species resembles *G. hedleyi* in having a pustulose protoconch and distinct second larval shell but differs in having a strong bifid carina on both the dorsal and ventral surfaces and in being higher relative to width. This rather poorly known species is found in the Barrington Tops-Gloucester Tops area and two specimens that appear to be this species are known from one location in the New England area considerably further north.

Glacidorbis troglodytes n.sp.

Derivation: *troglodytes* Greek (masculine) inhabitant of holes, caves etc.

Type material. HOLOTYPE, AMS C351666. PARATYPES: 1, AMS C350044; many, AMS C353961; 3, SAM D19069.

Type locality. One Tree Sink Hole (= Wurwurlooloo 5L7), near Mt Gambier, South Australia, 37°49.983'S 140° 46.983'E, in cave, 47 m deep, in fine silt/mud, 9 Feb 1988, M. Apathy (RAN).

Diagnosis. Very small (less than 1.1 mm in diameter), smooth or with a few weak spiral threads, initial part of protoconch sculptured with minute irregular pits.

Description. Shell (Figs. 2I, 6J–M) very small (up to 1.07 mm in max. diameter), orthostrophic, near planispiral, of up to about 2.2 whorls. Protoconch (Fig. 2 I) of about 1.4–1.5 whorls, first half whorl sculptured with very irregular pits, smaller and disappearing on next 0.4 whorls, last half whorl with fine axial threads only. Teleoconch sculpture of fine growth lines; holotype with few weak spiral threads on dorsal surface (Fig. 6J), but these subobsolete in some specimens. Dorsal and ventral surfaces of whorls convex, suture impressed; periphery of last whorl evenly convex. Base with broad, shallow umbilicus; ratio of umbilical width to maximum diameter 0.61. Aperture near circular (holotype and paratype examined using SEM). Colour white.

Dimensions. Table 13.

Operculum and radula unknown.

Table 13. Shell measurements of the types of *Glacidorbis troglodytes*.

dmin	dmax	mdht	mxht	aph	apw	whl
holotype						
0.88	1.15	0.29	0.46	0.45	0.44	2.10
paratype (AMS C350044)						
1.07	1.31	0.35	0.51	0.50	0.48	2.20

Distribution (Fig. 8). Known only from One Tree Sink Hole, near Mount Gambier, South Australia.

Remarks. This species is similar to *G. hedleyi* but differs in its more fragile, almost planispiral shell, its protoconch microsculpture of minute punctures rather than distinct pustules and in having weak to subobsolete spirals on the dorsal surface. While presently known from a single location, this species may occur in other sink holes in the Mount Gambier area.

Glacidorbis circulus n.sp.

Derivation: *circulus* (Latin), diminutive of *circus*—ring.

Type material. HOLOTYPE, AMS C371939. PARATYPES (29): 11, AMS C363863; 15, AMS C363865; 2, QMV; 1, TM E23419.

Type locality. Stn TA29, Marine Ck, tributary of Mersey R, NE of Railton, Tasmania, 41°19.3'S 146°22.383'E, 180 m, root mats hanging in water, 23 Jan 1987, WFP JHW & GAC, pH 6.50, cond. 0.09.

Additional paratypes. Stn TA30A, Marine Ck on Dallys Rd near Dulverton, NNW Railton, Tasmania, 41°18.78'S 146°23.2'E, 60 m, on gravel, leaves and stones, 23 Jan 1987, WFP JHW & GAC, pH 7.58, cond. 0.09 (AMS C363865).

Diagnosis. Shell with three strong dorsal and ventral spiral cords, innermost angulating whorl dorsally. Protoconch microsculpture of irregular pits.

Description. Shell (Figs. 2H, 14) very small (up to about 1 mm in max. diameter), orthostrophic, near planispiral, of about 2.5 whorls. Protoconch (Fig. 2H) of 1.3–1.4 whorls, sculptured with small, irregular pits. Teleoconch sculpture of fine growth lines and 3 strong, sharp spiral cords, innermost strongest and angulating whorl dorsally at about inner third, ventrally innermost two subequal or innermost stronger, whorl weakly angulated at innermost spiral. Dorsal surface inside main spiral strongly inclined towards suture; periphery of last whorl evenly convex; base convex to subangled. Base with broad umbilicus; ratio of umbilical width to maximum diameter 0.58–0.59. Aperture subcircular (examined using SEM from both type localities). Colour pale yellowish-white to white.

Dimensions. See Table 14.

Operculum oval (width /length 0.77–0.82), flat, of c. 3.5 (c. 1.5 adult) whorls; width of last whorl/length of operculum about 0.43. Nucleus large, spiral, eccentric. Inner

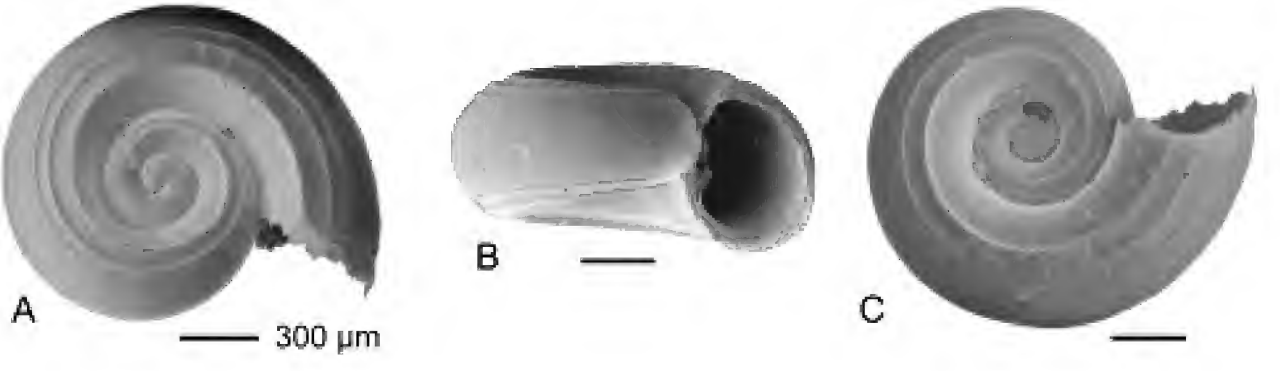

Figure 14. Shells of *Glacidorbis circulus* n.sp. A–C: holotype (AMS C371939); dorsal, lateral and ventral views.

Table 14. Shell measurements of the types of *Glacidorbis circulus*.

dmin	dmax	mdht	mxht	aph	apw	whl
holotype						
0.92	1.10	0.33	0.51	0.49	0.36	2.50
paratype (AMS C363865)						
0.78	0.97	0.34	0.50	0.47	0.33	2.30

surface with slightly raised spiral ridge surrounding most of nucleus. Exterior with numerous approximately spirally arranged pustules on last whorl (2 specimens examined from type locality).

Head-foot. Unpigmented.

Distribution (Fig. 8). Mid north coast, known only from Marine Creek, a tributary of the Mersey River.

Remarks. The shells of the two lots of this species are identical, both being collected at different locations in Marine Creek. Most specimens of both lots are slightly decalcified.

This species of *Glacidorbis* is one of two with multiple spirals on both ventral and dorsal surfaces. The other is *G. costatus* which has axial ribs as the predominant sculpture. *Glacidorbis circulus* is superficially similar to two species of *Striadorbis* described below but differs in the protoconch and opercular details that separate *Striadorbis* from *Glacidorbis*.

Glacidorbis? sp.

Type locality. Namba Formation in Union Corporation Bore GB, 70.10–71.63 m, in Lake Pundalpa area, 30°21'S 140°32'E.

Distribution. Middle Miocene deposits, Strezelecki Desert, Central Australia.

Remarks. This species was described in an unpublished report (Buonaiuto, 1982) and referred to by Bunn & Stoddart (1983) but, unfortunately, the 49 specimens on which the description was based cannot be located. From the illustrations and description the smooth shell resembles *G. hedleyi, G. occidentalis, G. tasmanicus* and *G. troglodytes*. The shells of the fossil taxon reach 2.6 mm in diameter and 1.3 mm in height and the protoconch was described as being of one whorl, smooth and undifferentiated from the teleoconch.

Benthodorbis n.gen.

Derivation: *bentho(s)* (Greek)—sea bottom; *dorbis*—derived from *Glacidorbis*.

Type species. *Glacidorbis pawpela* Smith, 1979.

Diagnosis. Shell with slightly hyperstrophically coiled shell; near planispiral, protoconch with axial and spiral threads, slightly heterostrophic. Teleoconch with few, rapidly increasing whorls sculptured with close collabral distinctly prosocline growth lines crossed by fine spiral striae; one species with weak spiral ridge ventrally, otherwise convex. Operculum paucispiral, lacking pustules on exterior, nucleus eccentric, whorls with slightly frilled edges. Radula as for family except mesocone with cusps right to tip and base expanding gradually, not expanded at right angles (Fig. 11K,L; Smith, 1979, figs. 5,6).

Remarks. Differs from *Glacidorbis* in having fine spiral and axial sculpture on the protoconch which lacks distinct punctures or pustules and has a smaller initial part of the first whorl. The teleoconch has fine spiral striae and the axial growth lines are markedly prosocline (orthocline in other glacidorbids). Unlike species of *Glacidorbis*, the base of the shell lacks a distinct umbilical area, being only slightly concave. The radula differs from all other known glacidorbids in having the base expanded gradually, not at right angles to the mesocone, so each tooth is nearly triangular in shape.

The two species of *Benthodorbis* are restricted to two old lakes in Tasmania where they live in the benthos in soft sediment.

Benthodorbis pawpela (Smith, 1979)

Glacidorbis pawpela Smith, 1979: 121, figs. 1,2 (part), 3–6; Smith & Kershaw, 1981: 44 (fig. in text, map 2, p. 119); Bunn & Stoddart, 1983: 55; Smith, 1992: 224.

Type material. HOLOTYPE, TM E10389. PARATYPES (7): 1, TM E10390 (examined wet, with shell intact); 6, MV F30143 (not examined).

Type locality. Elizabeth Bay, Great Lake, Tasmania, 41°54'S 146°46'E, from soft mud bottom at 30 m, W. Fulton, 7 Nov 1975, water temp. < 4°C; same locality, soft mud, 30–40 feet, W. Fulton & BJS, 1 Sep 1978, water temp. 3–4° (wet material from this latter lot examined and is registered MV F54872, 4 decalcified; MV F30147 and three specimens [removed from shells, with one badly damaged shell] and includes the specimen brooding embryos illustrated by Smith [1979, fig. 1]).

Additional material examined. TASMANIA: Elizabeth Bay, Great Lake, 41°54'S 146°46'E, 20 Apr 1977, W. Fulton (1, AMS C350042 ex IFCT); same loc. 30 m, from soft mud, 1 Sep 1978, W. Fulton & BJS (4, MV F54872), from soft mud, 1 Sep 1978, 9–12 m deep, W. Fulton & BJS (4, MV F30147).

Diagnosis. Maximum diameter of shell up to more than 4 mm in maximum diameter (usually more than 2.5 mm), with heterostrophic protoconch and evenly convex ventral surface. Spiral sculpture on teleoconch distinct, with granules at intersections of axial and spiral threads. Radula with 17–18 cusps on either side of mesocone.

Description. Shell (Fig. 15A–D,F) large for family (up to 4.4 mm in max. diameter), slightly hyperstrophic, of up to 3 whorls. Protoconch with initial whorl heterostrophic, of 1.4 whorls, sculptured with subobsolete spiral threads crossing minute, close axial threads, with minute granules at intersections. Teleoconch sculpture of weak prosocline growth lines and, on periphery and base, fine, closely-

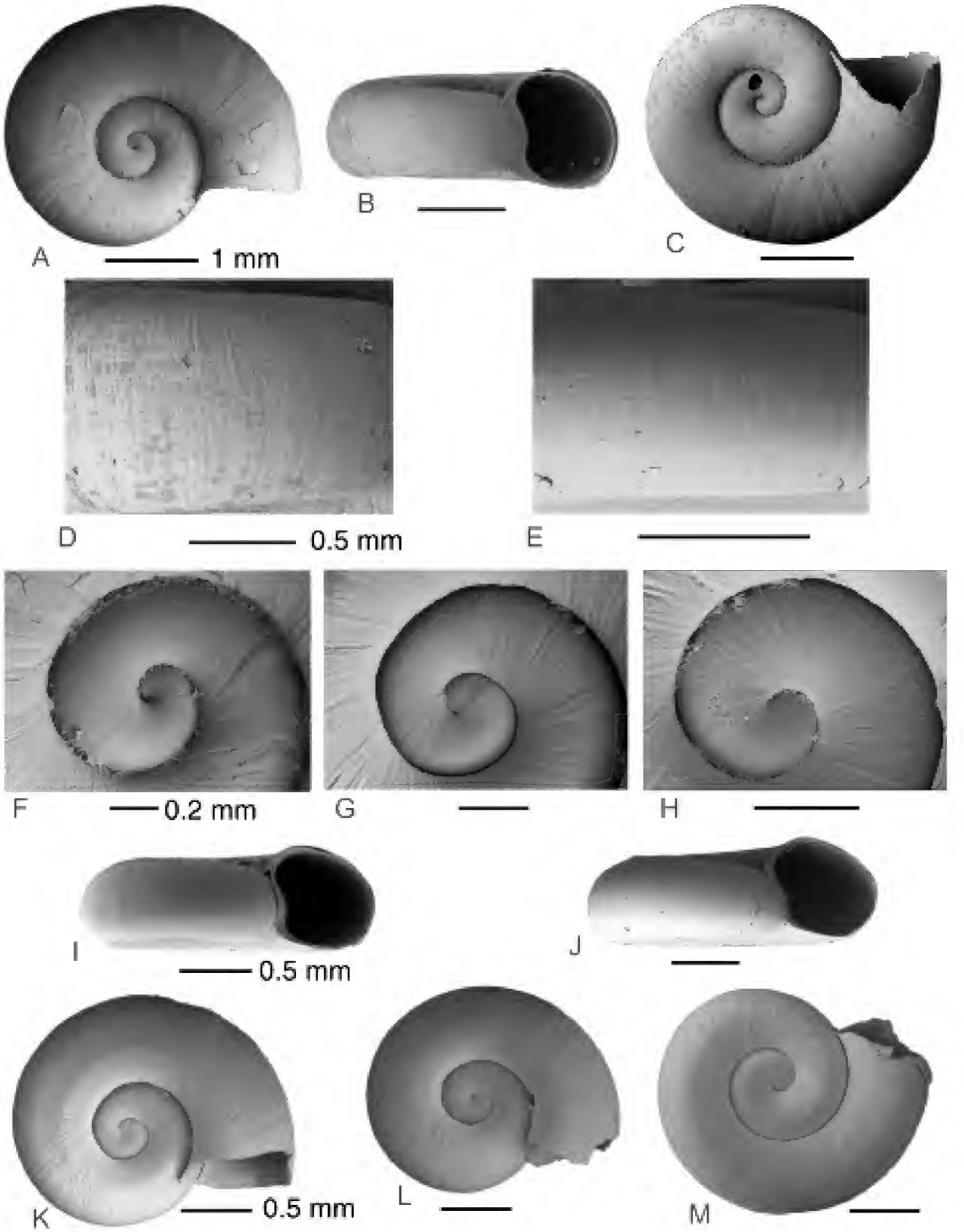

Figure 15. Shells of *Benthodorbis*. A–D,F: *Benthodorbis pawpela*; Elizabeth Bay, Great Lake, Tasmania (1, AMS C350042); A–C: dorsal, lateral and ventral views of one specimen; D: detail of sculpture on periphery of last whorl; F: protoconch. E,G–M: *Benthodorbis fultoni* n.sp.; Lake Sorell, Tasmania; E,G,J,K: holotype (MV F82303); E: detail of sculpture on periphery of last whorl; G: protoconch; J,K: lateral and dorsal views; H,I,L,M: paratype (MV F54907); H: protoconch; I,L,M: lateral, dorsal and ventral views (same specimen). Scale bar lengths indicated at the beginning of each row.

spaced, spiral threads, granulose at many intersections. Dorsal and ventral surfaces of whorls, and periphery convex, suture impressed; dorsally edge of whorl margining suture steep on last half of last whorl, slightly curved back towards outer edge of shell. Base with broad, shallow umbilical area. Aperture weakly pyriform (examined using SEM from AMS C350042). Colour brown, imparted by the rather thick periostracum.

Dimensions. See Tables 15 and 16.

Smith (1979: 122) notes that the shell of a dissected female has a maximum diameter of 4.4 mm and has 3 whorls, markedly larger than any of the measured types.

Operculum (Smith, 1979, fig. 4) paucispiral, oval, flat, of about 2.5 whorls (about 1.5 adult), last whorl wide, width of last whorl/length of operculum 0.34. Nucleus about 0.15 length of operculum, of about 1 whorl, eccentric. Inner surface and exterior microsculpture not described (details from Smith, 1979: 121 and fig. 4).

Radula (Smith, 1979: 121, figs. 5,6) of 22–26 rows. Central teeth with 17–18 sharp, approximately equal-sized lateral cusps occupying almost all length of mesocone. Base slightly wider than width of mesocone, dorsal basal thickening weak, anterior and posterior articulatory thickenings weakly developed, anterior articulation abuts tooth in front, anterior articulation stronger than posterior. Details of lateral elements unknown (details from figures and description of Smith, 1979).

Mantle cavity contains 5 embryos in the large female dissected by Smith (1979), the most anterior by far the largest, the shell being 1.3 mm in maximum diameter and of three quarters of a whorl.

Distribution (Fig. 17). Known only from Great Lake, Tasmania, at a depth of up to 30 m.

Remarks. Smith (1979) separated this species from the three other described species at the time (including *"G". magallanicus* Meier-Brook & Smith, 1976 from Chile) on the basis of its larger shell and the more numerous denticles on the central teeth of the radula. In addition, several important apomorphic characters of this species differentiate it from other members of the family. The granulose teleoconch sculpture is unique, as is the small initial whorl of the slightly heterostrophic protoconch. Moreover, the protoconch, like that of the next species, is weakly spirally sculptured and has distinct axial threads.

Table 15. Shell measurements of the types of *Benthodorbis pawpela* (from Smith, 1979).

dmin	dmax	whl
holotype		
3.0	3.6	2.75
paratypes		
2.2	2.7	2.0
1.6	2.2	1.5
2.5	3.0	2.5
3.1	3.7	2.75
2.5	3.0	2.25
1.9	2.5	1.75
1.9	2.4	1.5
2.0	2.5	1.75
2.9	3.5	2.5

Table 16. Shell measurements of a specimen of *Benthodorbis pawpela*.

dmin	dmax	mdht	mxht	aph	apw	whl
figured specimen (AMS C350042)						
2.82	3.43	1.03	1.44	1.37	1.25	2.25

Benthodorbis fultoni n.sp.

Derivation. Named for Dr Wayne Fulton, Director of the Inland Fisheries Commission of Tasmania, who collected the material.

Type material. HOLOTYPE, MV F82303 (ex 54905). PARATYPES (7): 1 dry, AMS C350043; 2 wet, MV F54905; 4 wet, MV F54907.

Type locality. Stn 5, Lake Sorell, Tasmania, 42°4.49'S 147°11.63'E, 02 Feb 1981, W. Fulton.

Additional material examined. TASMANIA: stn 3, Lake Sorell, 42°4.94'S 147°13.23'E, 27 Jan 1981, W. Fulton (2 wet, MV F54906).

Diagnosis. Maximum diameter of shell only slightly more than 2 mm, with near homostrophe protoconch and weak angulation or weak ridge on ventral side about ¾ of width of whorl from suture. Spiral sculpture on teleoconch weak and simple. Radula with 4 cusps on either side of mesocone.

Description. Shell (Fig. 15E,G–M) small (up to 2.1 mm in max. diameter), slightly hyperstrophic, of up to 2.3 whorls. Protoconch nearly homostrophic, of 1.2 whorls, sculptured with fine, closely spaced spiral threads crossing minute, close axial threads, with weak granules at intersections. Teleoconch sculpture of weak prosocline growth lines and a few weak spiral threads, especially on outer part of base. Dorsal surface of whorls convex, edge of whorl at suture very steeply inclined; suture impressed; periphery of last whorl evenly convex; ventral surface of last whorl with weak angulation or weak ridge at about ¾ of width of whorl from suture. Base with broad, shallow umbilical depression. Aperture sub-pyriform, slightly oblique (holotype and paratype examined using SEM). Colour white, periostracum brown.

Dimensions. See Table 17.

Operculum (Fig. 16F) paucispiral, oval, flat, of about 2.4 whorls (1.4 adult), last whorl wide, width of last whorl/length of operculum 0.37. Nucleus about 0.23 length of operculum, of about 1 whorl, eccentric. Inner surface not observed; exterior sculpture of growth lines only (one specimen examined by SEM from MV F54907).

Radula (Fig. 11K,L) with central teeth having about 4

Table 17. Shell measurements of types of *Benthodorbis fultoni*.

dmin	dmax	mdht	mxht	aph	apw	whl
holotype						
1.74	2.13	0.57	0.81	0.80	0.72	2.25
paratype (AMS C350043)						
1.58	1.91	0.54	0.76	0.72	0.64	2.10

sharp, approximately equal-sized lateral cusps occupying almost all length of mesocone. Base wider than width of mesocone, dorsal basal thickening weak, anterior and posterior articulatory thickenings weakly developed, anterior articulation slightly underlies tooth in front. Lateral elements parallel-sided, about 2.3 times longer than wide, narrowly spaced, details of inner surface not known (one specimen examined by SEM from MV F54907).

Distribution (Fig. 17). Lake Sorell, Tasmania.

Remarks. Smith (1985: 123) referred to this species as a "further, unknown species recorded from Lake Sorell (Fulton, 1983)". It differs from *B. pawpela* in its smaller shell, which has a near homostrophe protoconch with slightly larger initial whorl (although smaller than in species of *Glacidorbis* and *Tasmodorbis*), but has similar protoconch microsculpture. The ventral side has a weak angulation or weak ridge about ¾ of width of whorl from the suture whereas the whorls of *B. pawpela* are evenly convex. The teleoconch with similar microsculpture in the two species but the spirals are less distinct in *B. fultoni* and no granules are formed at the intersections of the spiral and axial threads.

While the radular details of both species are not particularly well known, *B. pawpela* differs markedly from *B. fultoni* in having many more cusps on the teeth (17–18 on each side compared with 4).

Striadorbis n.gen.

Derivation: *stria* (Latin)—furrow, channel, line; *dorbis*—derived from *Glacidorbis*.

Type species. *Valvata*(?) *pedderi* Smith, 1973.

Diagnosis. Shell differing from *Glacidorbis* in being planispiral, and in having spiral microsculpture on latter part of protoconch and (at least) early teleoconch. Protoconch with pustules in initial part, teleoconch whorls keeled or evenly rounded. Operculum circular with overlapping whorls and central nucleus. Radula with equal-sized cusps on mesocone but differs from *Glacidorbis* in having major articulation at posterior side of tooth base.

Remarks. Ponder (1986) provides some anatomical details of the type species, which differ from *G. hedleyi* in the following details: (*a*) the pallial cavity is longer and narrower and the rectum longer; (*b*) the mantle lobe is shorter; (*c*) the vagina is large and contains a prominent internal fold; and (*d*) the penis is narrower and the praeputium contains fewer glandular protuberances that are rounded distally, not disk-like as in *G. hedleyi*.

Like *G. hedleyi, Striadorbis pedderi* appears to be a protandrous hermaphrodite but, unlike *G. hedleyi*, no evidence suggests that brooding occurs in *S. pedderi* (see below).

The major articulation on the central teeth is reversed in *Striadorbis* compared with *Glacidorbis*, there being a large boss in front in *Glacidorbis* while the major thickening is posterior in *Striadorbis*. The condition in *Glacidorbis* is similar to that in *Gondwanorbis magallanicus* (Meier-Brook & Smith, 1976, fig. 7). The pustulose protoconch microsculpture is also seen in a few species of *Glacidorbis*.

Striadorbis pedderi (Smith, 1973)

Valvata(?) *pedderi* Smith, 1973: 430.

Glacidorbis pedderi.–Meier-Brook & Smith, 1976: 191; Smith, 1979: 123, fig. 2 (part); Smith & Kershaw, 1979: 41 (fig. in text); Smith & Kershaw, 1981: 43 (fig. in text, map 1 [p. 119]); Ponder, 1986: 75–76, fig. 21; Bunn & Stoddart, 1983: 55; Smith, 1992: 224.

Type material. HOLOTYPE, TM E8543. PARATYPES (6): 3, TM E6443, TM E8544; 1, MV F27938; 2, MV F27939 (on SEM stub), MV F27937 (serial sectioned individual) (details from Smith, 1973).

Type locality. In small hole in plain just south of Lake Edgar (now drowned as part of Lake Pedder), J.L. Hickman, 17 May 1972. Paratypes from Lake Pedder, Lake Maria, and Lake Edgar, in shallow water on weed and rushes with a net, J.A. Dartnall, 12 Feb 1967.

Additional material examined. TASMANIA: Lake Dora, 41°57'S 145°39'E, rock fauna, 18 Feb 1988, IFCT (7, AMS C354007); stn JW4, Orion Lake, Central, 41°36'S 146°12'E, short grassy weed beds near edge, 2 Feb 1988, JHW (7, AMS C363870); stn JW19, Lake Butters, E of Walls of Jerusalem, 41°48.9'S 146°22.6'E, 1250 m, rocky, cobbly shoreline, 5 Feb 1988, JHW (11, AMS C202326) (with *T. punctatus*); stn JW15, New Years Lake, N of Great Pine Tier, 41°50.4'S 146°22.8'E, at back of pond in water weed, 4 Feb 1988, JHW (1, AMS C363878); stn TA130, tributary of Split Rock Ck, 2.8 km NE of Liawenee on Lake Hwy, 41°52.8'S 146°41.283'E, 1040 m, in sedges, 7 Feb 1987, WFP & GAC (1, AMS C350048); stn JW13, Lake Rotuli, W of Great Pine Tier, 41°54.6'S 146°20.5'E, in sedges, 3 Feb 1988, JHW (2, AMS C202324); stn JW5, Junction Lake, SW of Lake Meston, 41°55.3'S 146°11'E, in sedge and algae, FBA sweeps, 2 Feb 1988, JHW (14, AMS C202319); stn JW24, Lake Olive—deep sided lake, near Great Pine Tier, 41°55.7'S 146°20.4'E, short turfy weed in shallows, 5 Feb 1988, 0–0.3 m deep, JHW (many, AMS C202327); Lake Naomi, 41°56'S 146°22'E, rock fauna, 27 Nov 1986, IFCT (1, AMS C354017); stn JW11, small lake south of Eagle Lake, 41°56.5'S 146°15.4'E, steep-sided muddy banks, seeps also muddy, 3 Feb 1988, JHW (10, AMS C202323); Orion Lakes, 41°57'S 146°8'E, rock fauna, 1 Feb 1988, IFCT (11, AMS C354025); stn JW10, Lake Malbena, 41°57'S 146°16.2'E, sedge swamp in one bay, lilies in another, 3 Feb 1988, JHW (many, AMS C202322); stn JW6, Ling Roth Lake, 41°57.2'S 146°13.2'E, 1020 m, bouldery shoreline, muddy silty substrate, 2 Feb 1988, JHW (6, AMS C363910); stn JW3, Lake Riengeena, SW of Mountains of Jupiter, 41°58.3'S 146°10.02'E, 1160 m, in gravel and weed along beach, 1 Feb 1988, JHW (4, AMS C363873); Lake Riengeena, 41°59'S 146°10'E, rock fauna, 1 Feb 1988, IFCT (several, AMS C354027); TA 615, Gordon River just below (downstream) Camerons Flat, 42°30.62'S

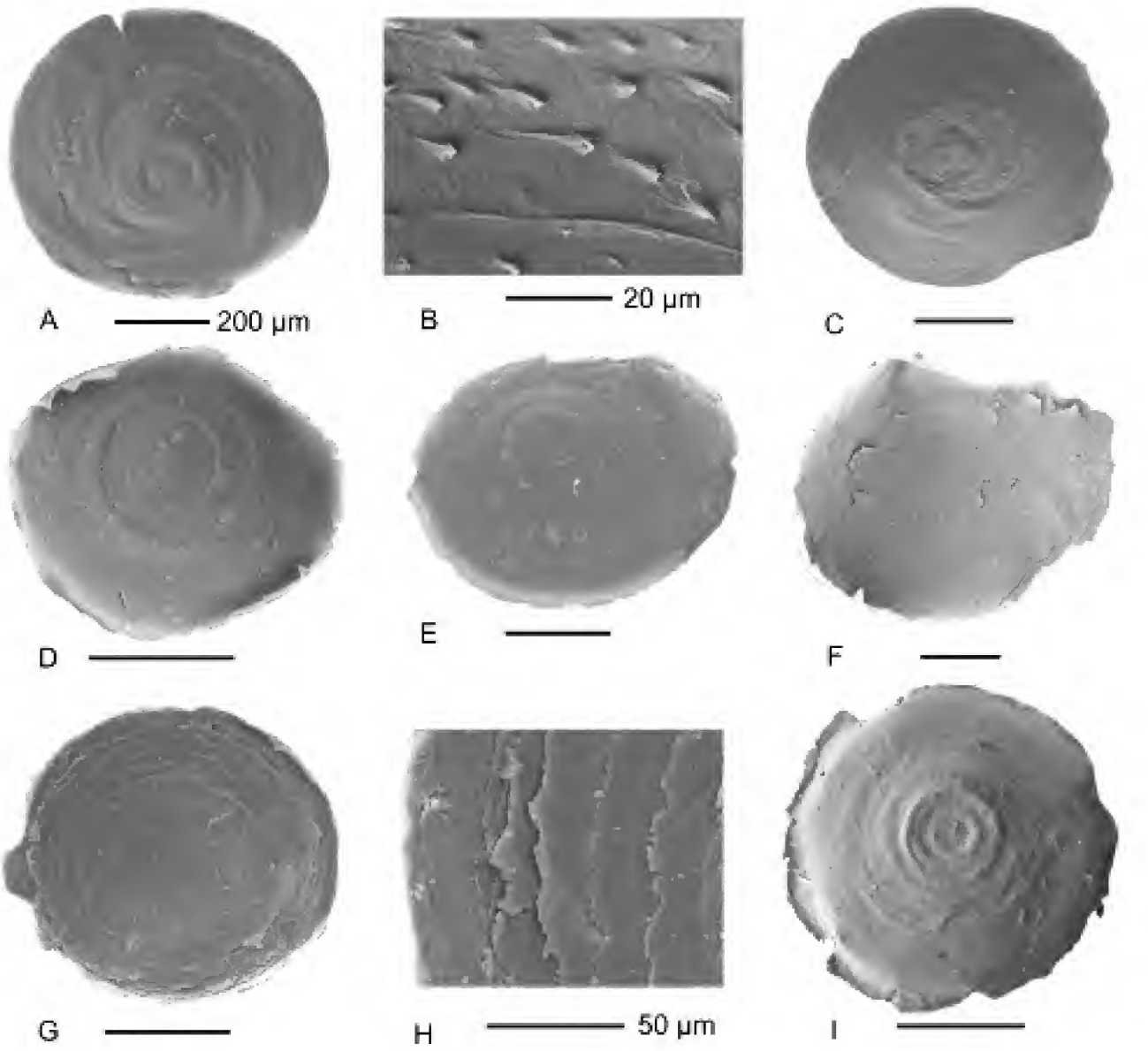

Figure 16. Opercula of *Striadorbis, Tasmodorbis* and *Benthodorbis*. A–C: *Striadorbis pedderi*. A,B: Gordon River just below Camerons Flat, SW Tasmania (AMS C350020); outer side and (B) detail of outer surface ornament. C: NE of Harlequin Hill 850 m off Scotts Peak Rd, SW Tasmania (AMS C202191); inner surface. D: *Striadorbis spiralis* n.sp.; Fitzroy River on Princes Hwy between Portland and Port Fairy, Victoria (paratypes, AMS C351209); outer side. E: *Striadorbis janetae* n.sp.; Last R., tributary of Ansons R. on Ansons Bay Rd, NE Tasmania (AMS C363861); outer side. F: *Benthodorbis fultoni* n.sp.; Lake Sorell, Tasmania (paratype, MV F54907); outer side. G–I: *Tasmodorbis punctatus* n.sp.; tributary Lockwood Ck, near end of Lockwood Creek Rd, NW Tasmania (AMS C364664); outer (G), inner (I) and detail of outer surface (H). Scale bars for figures A,C–G,I 200 µm.

145°40.5'E, small lake on E side, 14 Feb 1989, WFP & FEH (1, AMS C351674; many, AMS C353989; 2, AMS C350020); Lake Nive, 42°0'S 146°18'E, rock fauna, 2 Feb 1988, IFCT (3, AMS C354002); stn JW2A, unnamed lake between Travellers Rest Lake and Mountains of Jupiter, 42°0.3'S 146°13.5'E, 1120 m, 1 Feb 1988, JHW (10, AMS C363869); Lake Ina, 42°2'S 146°17'E, rock fauna, 1 Feb 1988, IFCT (2, AMS C353999); stn JW1, unnamed lake between Lakes Ina and Travellers Rest, 42°2.5'S 146°15.7'E, around boulders and in sedge, 1 Feb 1988, JHW (2, AMS C202316); stn JW37, Sandfly Ck at Scotts Peak Rd, 42°54.48'S 146°22.3'E, in tree roots and leaf litter, 11 Feb 1988, JHW (1, AMS C363866); Sanctuary Lake, 42°56'S 146°2'E, rock fauna, 18 Feb 1989, IFCT (many, AMS C354026); stn C179T, NE of Harlequin Hill 850 m off Scotts Peak Rd, 42°58.32'S 146°20.95'E, 260 m, in swamp, on submerged moss in sluggish main pond, 27 Jan 1982, WFP JH & WFPj (3, AMS C202191; many, AMS C355561); stn SWT2, Davey River, above gorge, 43°9'S 145°56'E, 40 m, under large boulders, on sand/gravel base, 10 Feb 1987, JHW (1, AMS C202310); stn TA42, Brushy Rivulet on Bryans Rd WSW of Birralee, Tasmania, 41°25.983'S 146°44.2'E, in weed, 25 Jan 1987, WFP JHW & GAC (1, AMS C354939) (one poor specimen tentatively assigned to this species).

Decalcified material identified as "G." pedderi by B.J. Smith. Stn GR221, Gordon River, just upstream from Butler Island, "perched" lake, 42°33.78'S 145°40.43'E, on aquatic plants, 25 Jan 1976, Uni. of Tas.

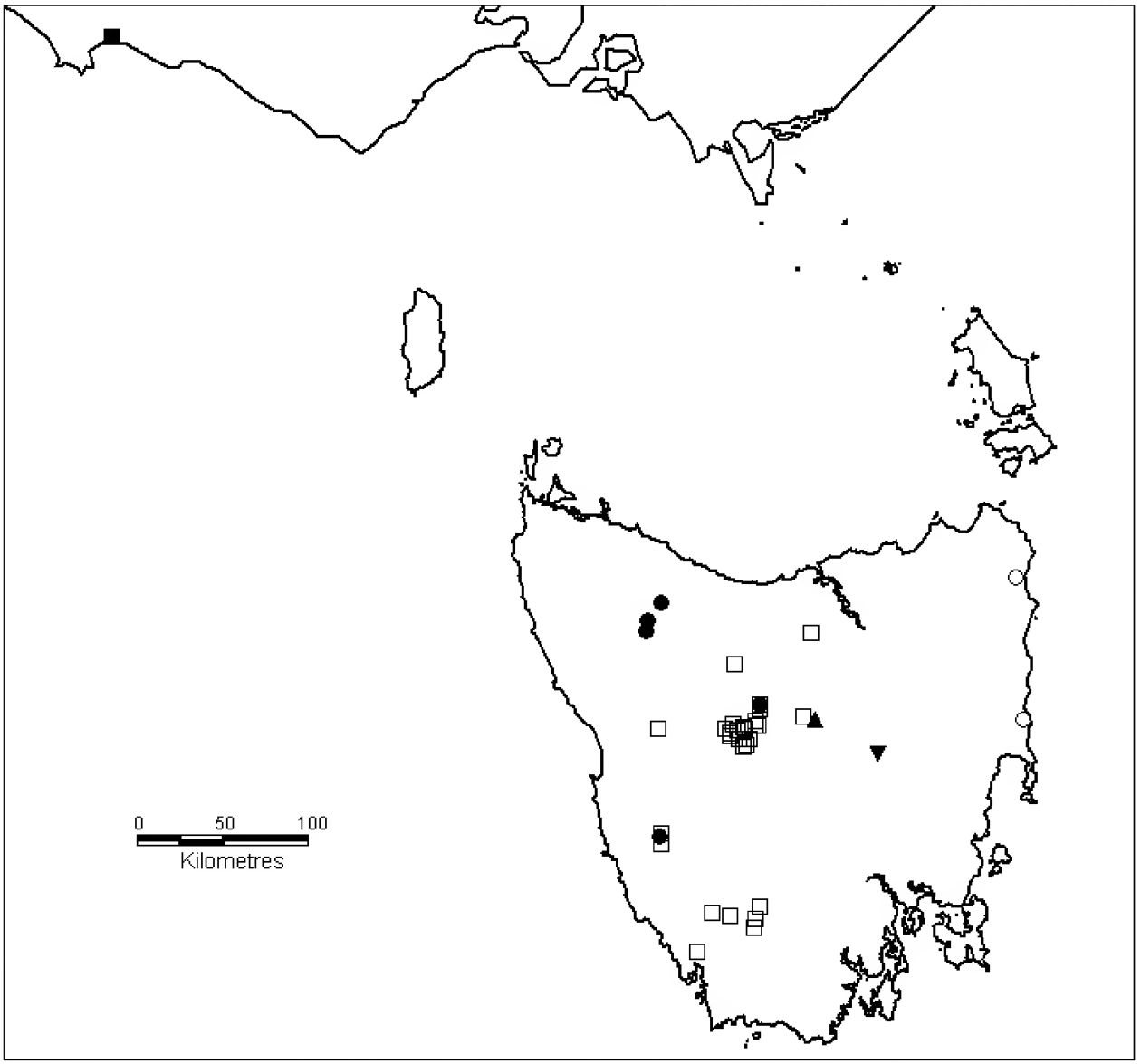

Figure 17. Distribution of species *Benthodorbis pawpela* (▲), *B. fultoni* (▼), *Striadorbis pedderi* (□), *S. spiralis* (■), *S. janetae* (○) and *Tasmodorbis punctatus* (●).

(several, MV F54904; 5, MV F54909); Lake Pedder, 42°57'S 146°10'E, 10 Mar 1972, A. Neboiss (1, MV F54903); Lake Edgar, 43°1'S 146°20'E, open water, 17 May 1972, Uni. of Tas. (2, MV F54873; 3, MV F54874).

Diagnosis. Shell with keel on mid-dorsal and mid ventral surface of whorls, fine spiral threads present over whole surface or mainly on juvenile shell; periphery usually with spiral threads.

Description. Shell (Figs. 18A–C,F; 19) small (up to 2 mm in max. diameter), planispiral, of up to 3.25 bicarinate whorls. Protoconch (Fig. 18A–C,F) of about 1.2 convex whorls (distinction between protoconch and teleoconch not clear), initial part sculptured with small pustules, latter part with several (approx. 8–10) rather uniform spiral threads that continue on to teleoconch. Teleoconch sculpture of axial growth lines crossed by few spiral threads which become subobsolete to obsolete on last whorl in typical specimens, in others remaining across last whorl; prominent sharp spiral keel in middle of dorsal and ventral parts of whorl, weak ventrally in some specimens. Periphery of last whorl evenly convex, usually with spiral threads. Base with broad, shallow umbilicus bordered by keel or ridge, ratio of umbilical width to maximum diameter 0.8. Aperture subcircular except for dorsal and ventral angulations caused by spiral keels (examined using SEM from AMS C202191, AMS C350020 and AMS C350048). Colour yellow-brown to yellow, with last part of last whorl white to transparent.

Dimensions. See Tables 18 and 19.

Operculum (Fig. 16A–C) circular, concave, of c. 4.5 (about 2.5 adult) overlapping whorls but difficult to estimate, width of last whorl/length of operculum 0.18. Nucleus large, about 0.19–0.25 width of operculum, appears

to be spiral, perhaps with about 2 whorls, central. Inner surface with weak rim around nucleus. Exterior with about 10–13 rather irregular rows of spirally arranged pustules on last whorl (examined using SEM, 3 specimens from AMS C202191 and 2 from AMS C350020).

Table 18. Shell measurements of types of *Striadorbis pedderi* (from Smith, 1973).

dmin	dmax	mxht	whl
holotype			
1.61	1.96	0.88	3.0
paratypes			
1.00	1.23	0.42	
1.00	1.23	0.58	
0.85	1.11	0.58	
1.04	1.35		3.0
1.31	1.65		3.0

Radula (Fig. 20A,D,F) of 15–21 rows. Central teeth with 7–8 sharp, approximately equal-sized lateral cusps (some bifid on some teeth in specimen from AMS C202191) occupying about ⅔ length of mesocone. Base 3 times wider than long, about twice width of mesocone; outer edges straight to slightly convex, dorsal basal thickening well developed and clearly delineated, anterior articulatory thickening weaker than posterior articulatory thickening, anterior articulation overlapped by tooth in front. Width of lateral elements about ⅔ length, slightly tapering distally, with rounded, slightly thickened inner ends, spaced at about ¼ of maximum width (examined using SEM, 3 from AMS C202191 and 2 from AMS C350020).

Table 19. Shell measurements of *Striadorbis pedderi*.

dmin	dmax	mdht	mxht	aph	apw	whl
figured specimens (AMS C202191)						
1.53	1.78	0.45	0.68	0.62	0.55	2.65
1.25	1.48	0.38	0.64	0.59	0.51	2.30
1.42	1.70	0.45	0.61	0.57	0.59	2.55
figured specimens AMS C350020						
1.64	1.96	0.50	0.69	0.68	0.66	2.65
1.50	1.77	0.46	0.66	0.63	0.55	2.70
additional specimen (AMS C350048)						
1.59	1.94	0.44	0.74	0.65	0.62	2.55
additional specimen (AMS C351674)						
1.74	2.02	0.51	0.66	0.65	0.61	3.00

Distribution (Fig. 17). Although originally described from (the present) Lake Pedder, this species was recorded from three additional localities by Smith (1979). These are: small perched lake, just upstream from Butlers Island, lower Gordon River (confirmed as *G. pedderi*); Cleveland, W. Tasmania (material not seen but, judging from the locality, it is probably *G. decoratus*); Dip River Falls, NW Tasmania

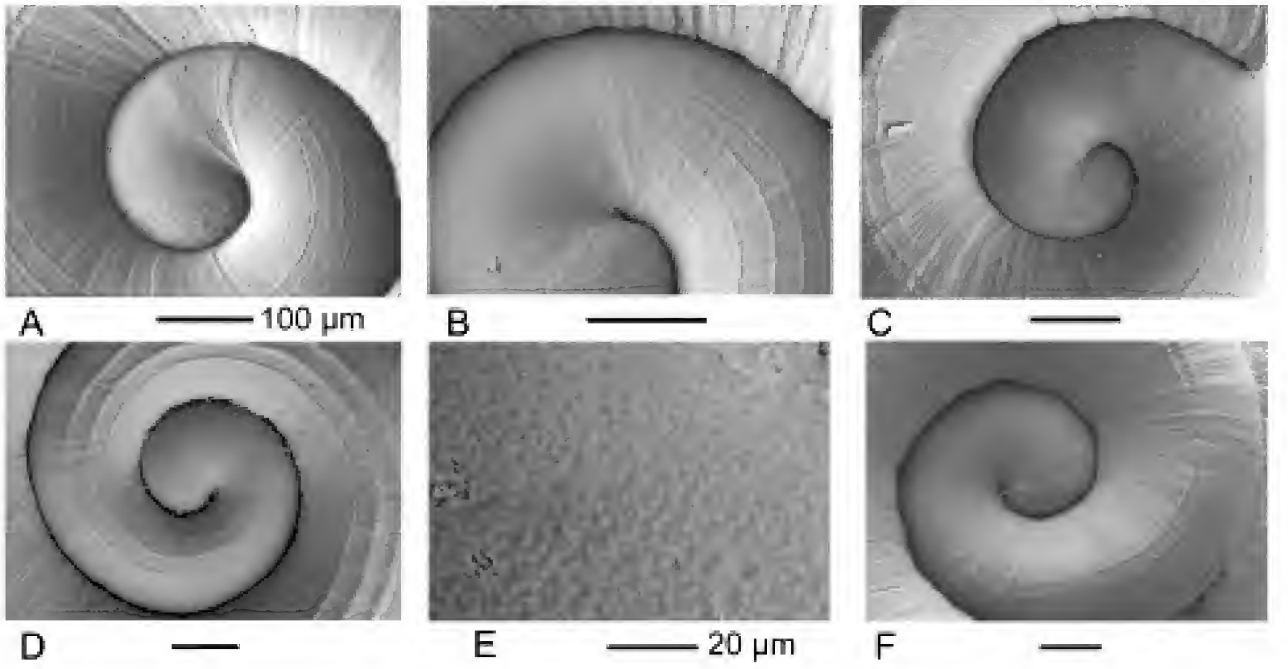

Figure 18. Protoconchs of *Striadorbis*. A–C,F: *Striadorbis pedderi*. A: tributary of Split Rock Ck, 2.8 km NE of Liawenee on Lake Hwy, Tasmania (AMS C350048). B: Gordon River just below Camerons Flat, SW Tasmania (AMS C350020). C,F: NE of Harlequin Hill 850 m off Scotts Peak Rd, SW Tasmania (AMS C202191); dorsal (C) and ventral (F) views. D,E: *Striadorbis spiralis* n.sp.; Fitzroy River on Princes Hwy between Portland and Port Fairy, Victoria (paratype, AMS C351209); detail of microsculpture on initial whorl (E). Scale bars for A–D and F 100 µm.

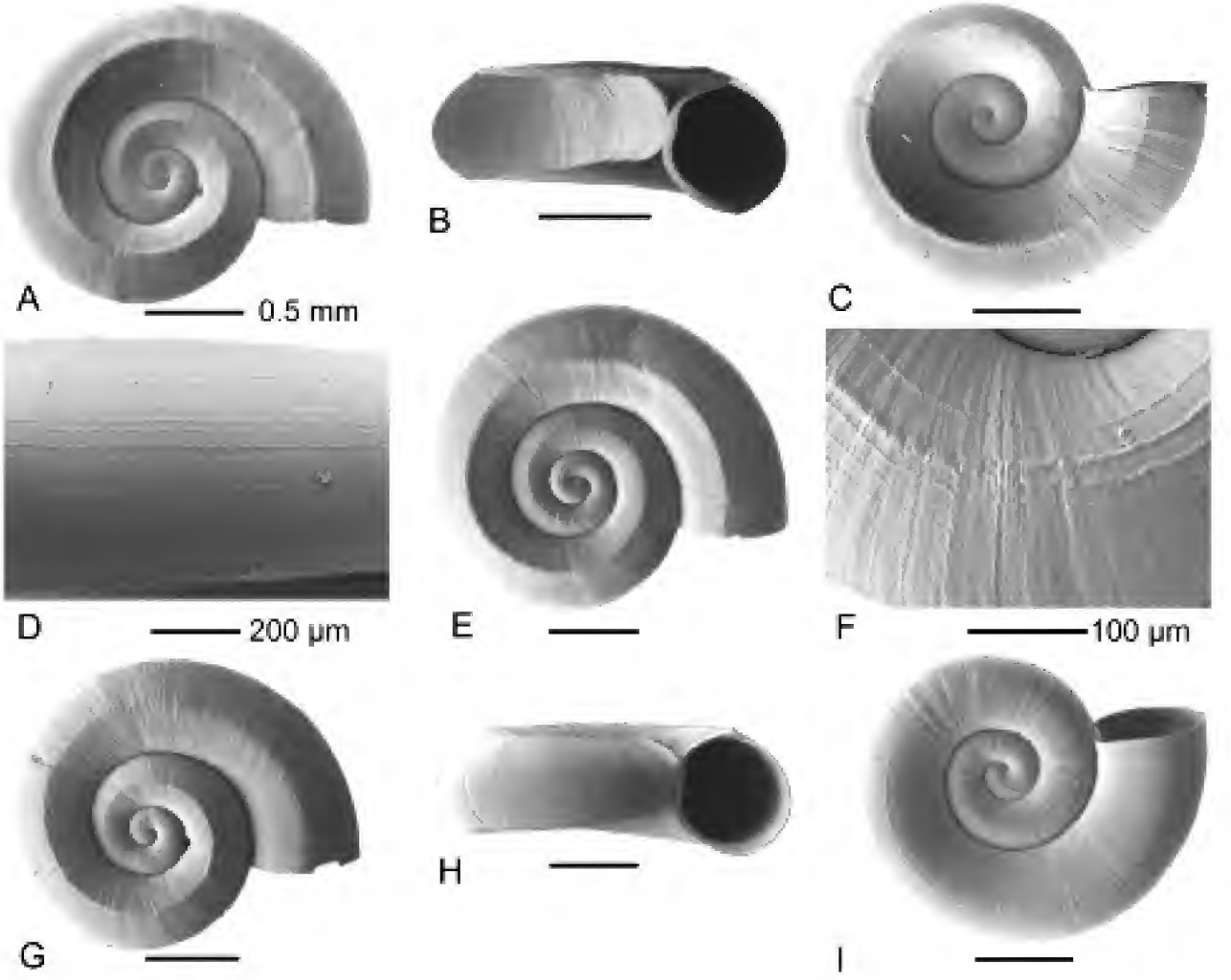

Figure 19. Shells of *Striadorbis pedderi*. A–C: NE of Harlequin Hill 850 m off Scotts Peak Rd, SW Tasmania (AMS C202191); dorsal, lateral and ventral views. D–F,H,I: Gordon River just below Camerons Flat, SW Tasmania (AMS C350020); detail of sculpture on periphery (D). E,H,I: dorsal, lateral and ventral views. F: detail of sculpture on ventral side of last whorl of a subadult. G: tributary of Split Rock Ck, 2.8 km NE of Liawenee on Lake Hwy, Tasmania (1, AMS C350048); dorsal view. Scale bars A–C, E, G–I 0.5 mm.

(*Glacidorbis atrophus*). These localities were mapped in Smith & Kershaw (1981).

Remarks. Smith (1973) described the shell surface as being composed of an "irregular lattice of crystal elements". In fact, the surface of the holotype is corroded (see also Smith, 1973, fig. 5). The radular mount illustrated by Smith (1973) does not show the lateral elements clearly, although their presence is suggested in his figs. 7 and 9. Smith (1973, 1979) and Ponder (1986) did not record ovovivipary in this species and, as it has not been seen it in the specimens examined in this study, it appears that it does not brood capsules.

Some specimens differ from typical *T. pedderi* in having a weak basal ridge (Fig. 19 I), weaker dorsal keel (Fig. 19H) and more distinct spiral threads over most of the teleoconch surface (Fig. 19H–I). Intermediate examples are found and there is no clear cut geographic pattern so these morphs are considered to be conspecific.

Striadorbis spiralis n.sp.

Derivation: *spiralis* (Latin)—spiral.

Type material. HOLOTYPE, AMS C350959. PARATYPES: many, AMS C351209; 7, AMS C302484; 1, AMS C302485; 1, AMS C353965; 4, MV F82299.

Type locality. Stn WVIC13, Fitzroy River on Princes Hwy between Portland and Port Fairy, Victoria, 38°13.29'S 141°45.79'E, amongst roots of willows and *Leptospermum*, 4 Jan 1999, WFP.

Additional paratypes. Stn VIC26, Fitzroy River at Princes Hwy, E of Portland, Victoria, 38°13.51'S 141°45.61'E, in roots and weed, 18 Feb 1994, 10, GAC & ACM, pH 7.79, cond. 1.93 (7, AMS C302484; 2, AMS C302485; 1, AMS C350959; 1, AMS C353965).

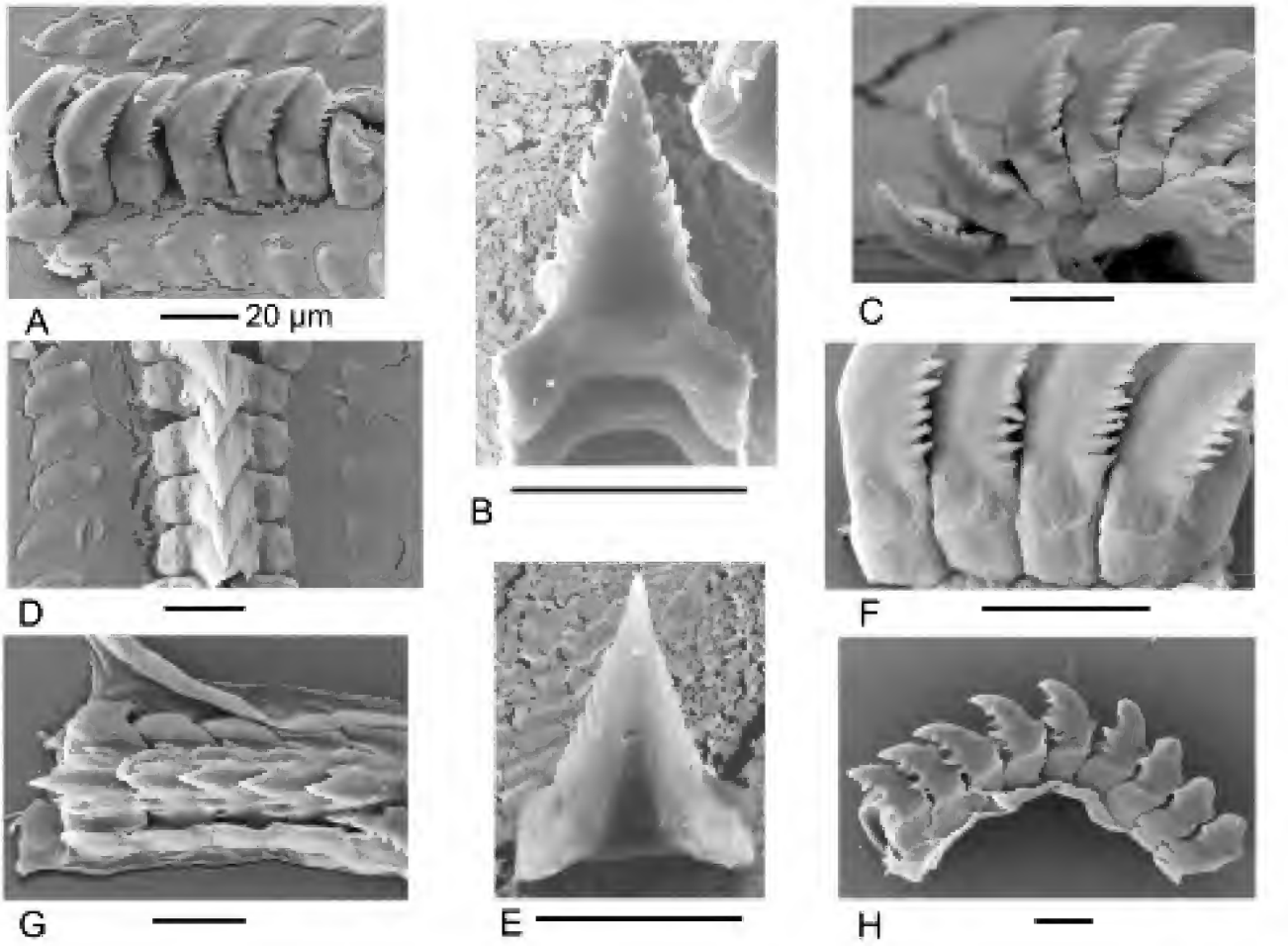

Figure 20. Radulae of *Striadorbis* and *Tasmodorbis*. A,D,F: *Striadorbis pedderi*; NE of Harlequin Hill 850 m off Scotts Peak Rd, SW Tasmania (AMS C202191); lateral (A,F) and dorsal (D) views. B,C,E: *Striadorbis spiralis* n.sp.; Fitzroy River on Princes Hwy between Portland and Port Fairy, Victoria (paratypes, AMS C351209); lateral view (C) and separate teeth, anterior face (B), posterior face (E). G,H: *Tasmodorbis punctatus* n.sp.; tributary Lockwood Ck, near end of Lockwood Creek Rd, NW Tasmania (AMS C364664); dorsal and lateral views.

Diagnosis. Shell with evenly convex whorls having 3–4 strong spiral threads on upper and lower surfaces that persist over whole shell, as well as several weaker spirals; periphery lacking spiral threads.

Description. Shell (Figs. 18D,E; 21A–C) very small (up to 1.2 mm in max. diameter), planispiral, of about 2.4 whorls. Protoconch (Fig. 16D,E) of 1.3 whorls, first ⅓ whorl sculptured with minute pustules, remaining whorl with 3 strong and 1 weaker spiral threads. Teleoconch sculpture of 2–3 strong spiral threads on middle of both dorsal and ventral surfaces; a few (1–3) weaker threads also present on outside and 0–2 inside strong spirals. Dorsal and ventral surfaces of whorls convex; periphery of last whorl evenly convex, smooth. Base with broad, shallow umbilicus; ratio of umbilical width to maximum diameter 0.69–0.71. Aperture near circular (type material and 3 specimens from AMS C302485 examined using SEM). Colour pale yellow to orange brown, semi-transparent.

Dimensions. See Table 20.

Operculum (Fig. 16D) circular, concave, of c. 4.6 (adult 2.6) overlapping whorls, width of last whorl/length of operculum 0.28–0.29. Nucleus large, 0.28–0.29 length of operculum, spiral (about 2 whorls), central. Inner surface simple. Exterior with several very irregular rows of spirally arranged pustules on last whorl (examined using SEM from 2 specimens from type locality).

Radula (Fig. 20B,C,E) of 17+ rows. Central teeth with 6–8 (usually 7) sharp, approximately equal-sized lateral cusps occupying about ⅔ length of mesocone. Base 2.7–2.8 wider than long, about 1.6 wider than width of mesocone, outer edges slightly concave, dorsal basal thickening rather weak, anterior articulatory thickening weaker than posterior, anterior articulation overlapped slightly by tooth in front. Details of lateral elements not available from mount (2 specimens examined using SEM from type locality).

Several preserved specimens were examined and none contained brooded embryos. The head-foot is unpigmented and the body (as seen through the shell) is covered with small black blotches.

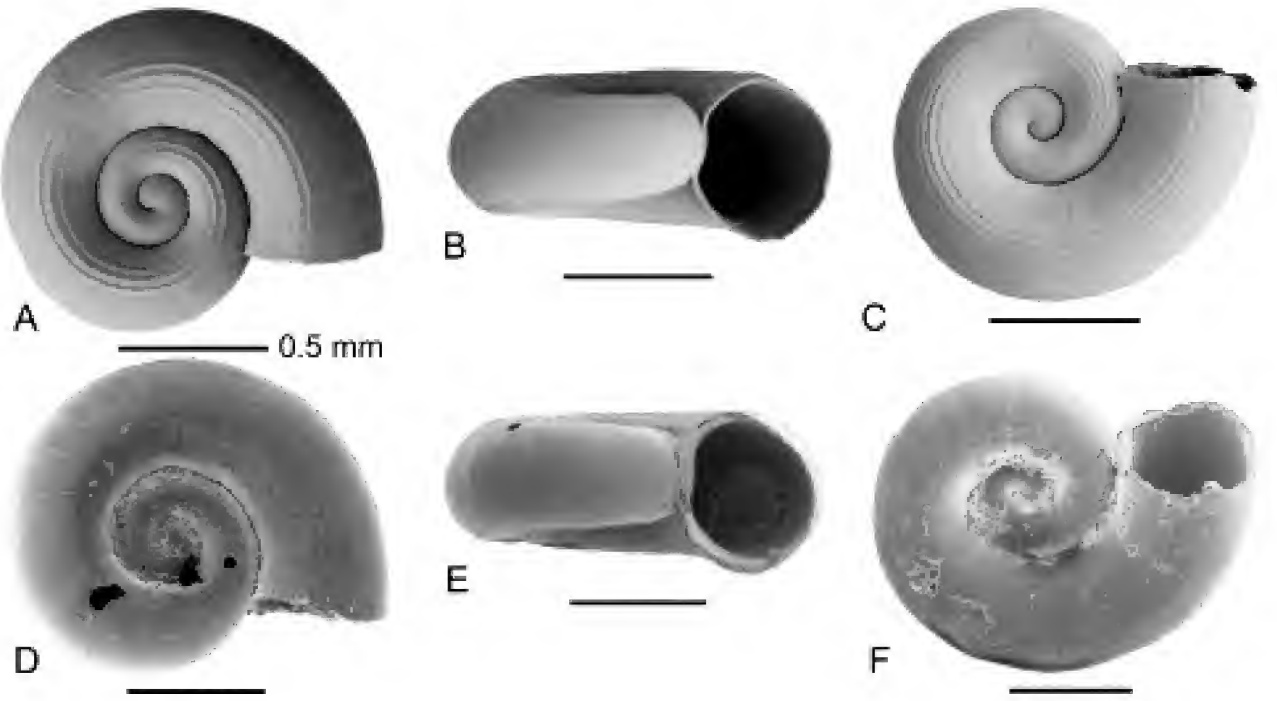

Figure 21. Shells of *Striadorbis*. A–C: *Striadorbis spiralis* n.sp.; dorsal view of holotype (A) (AMS C350959). B,C: Fitzroy River on Princes Hwy between Portland and Port Fairy, Victoria (paratypes, AMS C351209); lateral and ventral views of two specimens. D–F: *Striadorbis janetae* n.sp.; holotype (AMS C369814); dorsal, lateral and ventral views.

Table 20. Shell measurements of types of *Striadorbis spiralis*.

dmin	dmax	mdht	mxht	aph	apw	whl
holotype						
0.87	1.06	0.26	0.50	0.46	0.37	2.60
figured paratype (AMS C351209)						
0.78	0.96	0.25	0.41	0.41	0.33	2.20
paratype (AMS C350959)						
1.21	1.43	0.41	0.63	0.57	0.48	2.40
paratypes (AMS C302485)						
0.86	1.05	0.29	0.49	0.48	0.41	2.20
0.90	1.17	0.30	0.49	0.47	0.42	2.25

Distribution (Fig. 17). Known only from the one locality in the Fitzroy River, Western Victoria.

Remarks. This species is placed in *Striadorbis* because its protoconch and opercular characters closely resemble those of *T. pedderi*. It differs from that species in lacking a distinct dorsal and ventral keel, in having several distinct spiral ridges and in lacking spiral threads on the periphery.

While this species appears to have a restricted distribution, more sampling is required in the area to ascertain its actual range. Extensive sampling by WFP in the Fitzroy River further upstream in the vicinity of Heywood failed to locate this species.

Striadorbis janetae n.sp.

Derivation. Named for Janet MacIntosh (née Waterhouse) in recognition of her expertise in collecting glacidorbids.

Type material. HOLOTYPE, AMS C369814. PARATYPE (1): AMS C363861.

Type locality. Stn TA99, Last River, tributary of Ansons R on Ansons Bay Rd, Tasmania, 41°8.2'S 148°11.7'E, 80 m, 31 Jan 1987, WFP JHW & GAC, pH 6.75, cond. 0.18 (AMS C363861).

Additional material examined. TASMANIA: Stn C68T, Apsley River on Hwy 3, 41°54'S 148°15'E, on stones and weed, 16 Jan 1982, 15, WFP JH & WFPj (1, AMS C202174).

Diagnosis. Shell with slightly angulated whorls having one strong spiral thread on upper and lower surfaces that persists over whole shell, as well as several weaker spirals; periphery smooth.

Description. Shell (Figs. 21D–F) very small (up to 1.5 mm in max. diameter), planispiral, of about 2.5 whorls. Protoconch of about whorls, first third whorl sculptured with minute pustules, remainder of whorl with two moderately strong spiral threads (protoconch details from AMS C202174). Teleoconch sculpture of one strong spiral thread at middle of both dorsal and ventral surfaces forming weak subangulation; 2–3 weaker spiral threads also present inside and 5–6 outside main spiral dorsally and 3–5 inside

and up to 8 outside ventrally. Dorsal and ventral surfaces of whorls convex; periphery of last whorl evenly convex, smooth. Base with broad, shallow umbilicus; ratio of umbilical width to maximum diameter 0.70–0.75. Aperture near circular (holotype and specimen from AMS C202174 examined using SEM). Colour yellowish-white.

Dimensions. See Table 21.

Table 21. Shell measurements of the types of *Striadorbis janetae*.

dmin	dmax	dht	mxht	aph	apw	whl
holotype						
1.21	1.50	0.39	0.55	0.64	0.53	2.5
additional specimen AMS C202174						
0.93	1.14	0.34	0.47	0.48	0.40	2.3

Operculum (Fig. 16E) circular, slightly concave, of c. 4.5 (adult 2.5) overlapping whorls, width of last whorl/ length of operculum 0.19. Nucleus large, about 0.33 length of operculum, spiral (about 2 whorls), central. Inner surface not examined. Exterior with several irregular rows of spirally arranged pustules on last whorl (operculum of holotype examined using SEM).

Radula. Not examined.

Head-foot. Unpigmented.

Distribution (Fig. 17). NE coast, in eastward-flowing drainages.

Remarks. This Tasmanian species resembles the western Victorian *S. spiralis*, the shell differing in having a single spiral thread (not 2) dominating dorsally and ventrally. This spiral weakly subangulates the whorl above and below while in *S. spiralis* the dorsal and ventral surfaces of the whorls are evenly convex. *Striadorbis janetae* differs from *S. pedderi* in having weakly subangled whorls dorsally and ventrally (not strongly keeled), in being smaller, in having the secondary spirals more strongly developed and lacking spiral threads on the periphery.

The material for this species is poor. The holotype, being only one of two specimens available from the type locality. Only one other specimen is assigned to this species. It is from the Apsley River, a catchment further south than the type locality, but also an east coast drainage. The holotype has a weaker median spiral than the Apsley River specimen. The holotype has 3 spiral threads inside the main dorsal spiral and 6 outside and, on the base, has 5 outside and 8 inside. The Apsley River specimen (which is smaller and probably somewhat immature) has 2 spirals inside and 5 outside the main dorsal spiral and 3 inside and 2 outside the primary basal spiral. The greatly increased number of spirals on the base in the type are attributable to the spirals continuing onto the inner base, the inner-most next to the suture, whereas in the Apsley River specimen the spirals are confined to the middle part of the whorl. The determination of the significance of these differences will have to await examination of additional material.

Tasmodorbis n.gen.

Derivation: *tasmo*—derived from Tasmania; *dorbis*—derived from *Glacidorbis*.

Type species: *Tasmodorbis punctatus* n.sp.

Diagnosis. Shell planorbid-like, planispiral to slightly hyperstrophic, protoconch with initial part distinctly inclined downwards, sculptured with close rounded axial ribs and very close, even spiral threads. Rest of shell simple, with convex whorls and close collabral growth lines, less tightly coiled than in other members of family. Interior of shell with shell pores. Radula similar to *Glacidorbis* but with one (or rarely two) cusps at lower ⅓ of mesocone much larger than others and base with articulatory elements thrust forwards so point of articulation lies beneath middle of tooth in front. Base not acutely expanded, shape of tooth approximately triangular. Lateral elements similar to *Glacidorbis*, untanned, broad, about as long as base of central teeth. Operculum circular, multispiral and lacking pustules on external surface. Anatomy unknown.

Remarks. This genus differs from *Glacidorbis* and other glacidorbid genera in at least four important characters: (*a*) the nature of the axial and spiral microsculpture on the protoconch, (*b*) the details of the central teeth (see diagnosis), (*c*) the circular, multispiral operculum and (*d*) the shell pores on the inner surface of the shell. *Striadorbis* has a circular operculum but in that genus it is paucispiral. No other glacidorbid has shell pores, protoconch microsculpture or radular characters like *T. punctatus*. The shell coiling is also looser than in other glacidorbids. As in species of *Benthodorbis*, there is no distinct umbilical area because of the very shallow, slightly concave base.

The articulation of the teeth bases is unlike other Australian members of the family but possibly resembles that in *Gondwanorbis magallanicus* (see Meier-Brook & Smith, 1976, fig. 4).

The shell pores are, as far as is known (condition in *Gondwanorbis* unknown), unique in this family and are possessed by relatively few gastropods (see Reindl & Haszprunar, 1994 for a recent review). They are illustrated in Figures 22G–I, K. Each consists of an expanded, cone-like entrance (Fig. 22H,K) constricting to a narrow, straight tube that penetrates deep into the shell (Fig. 22G,I). These tubes were not traced to the surface in the preparations examined and no openings were visible on the outer surface.

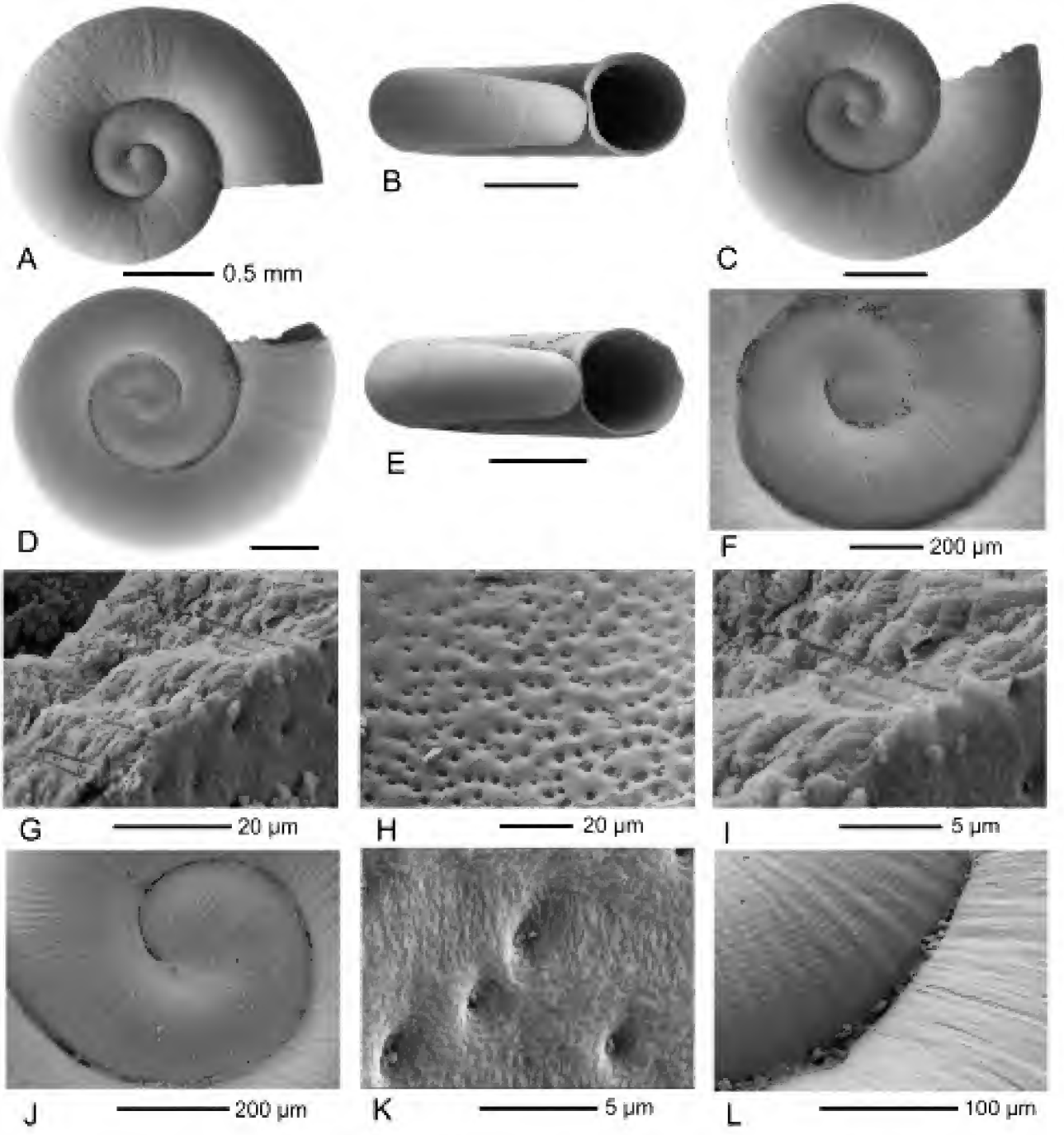

Figure 22. Shell of *Tasmodorbis punctatus* n.sp. A: holotype (AMS C351678); dorsal view. B–L: Wandle River on Murchison Hwy, N of Waratah, NW Tasmania (AMS C202187). B–E: lateral and ventral views of four specimens. F: ventral view of protoconch. G,I: fractured shell surface at different magnifications showing tubes through shell from punctures. H,K: punctures on inner surface of shell. K: shows high power detail. J: dorsal view of protoconch. L: detail of sculpture on latter part of protoconch and early teleoconch.

Tasmodorbis punctatus n.sp.

Derivation: *punctatus* (Latin)—small puncture.

Type material. HOLOTYPE, AMS C351678. PARATYPES (9): 7, AMS C202187; 1, TM E23421; 1, QVM 9:16235.

Type locality. Stn C139T, Wandle River on Murchison Hwy, N of Waratah, Tasmania, 41°21.81'S 145°34.83'E, 565 m, on weed and roots and on and under stones, 23 Jan 1982, 565, WFP JH & WFPj.

Additional material examined. TASMANIA: stn TA526B, tributary Lockwood Ck, near end of Lockwood Creek Rd, 41°16'S 145°40'E, 540 m, leaf litter, 7 Feb 1989, WFP JHW & FEH, pH 6.21, cond. 0.07 (16 [decalcified—radula examined], AMS C364664); stn C140T, Deep Gully Creek, tributary of Arthur River, at Murchison Hwy, 41°25.467'S 145°33.7'E, rocks and gravel in large stream, 23 Jan 1982, WFP WFPj & JH (4, AMS C366183); stn JW19, Lake Butters, E of Walls of Jerusalem, 41°48.9'S 146°22.6'E, 1250 m, rocky, cobbly shoreline, 5 Feb 1988, JHW (3, AMS C355560) (with *S. pedderi*); stn TA628C, tributary of Gordon River, 1.2 km N of Snag Point on W side of river, 42°31.383'S 145°40.067'E, 40 m, in seepage, 15 Feb 1989, WFP & FEH (2, AMS C354938).

Diagnosis. Shell smooth, more loosely coiled than other members of family, with punctures on inner shell surface and multispiral operculum.

Description. Shell (Fig. 22) small (up to 2.1 mm in max. diameter), normally planispiral, of about 2.3 convex whorls. Protoconch of 1.4 whorls, initial part strongly inclined downwards, sculptured with low, narrow, rounded axial folds crossed by numerous spiral threads with linear interspaces which form tiny rectangular pustules at intersections. Teleoconch sculpture of fine, irregular axial growth lines. Dorsal surface of whorls convex near suture, sutures impressed; periphery of last whorl evenly convex; ventral surface of last whorl convex. Base with broad, shallow umbilicus; ratio of umbilical width to maximum diameter about 0.70. Aperture circular (examined using SEM from type locality). Colour dark brown, with last part of last whorl yellow-white.

Dimensions. See Table 22.

Operculum (Fig. 16G–I) circular, concave, of c. 7 overlapping whorls with edges frilled, width of last whorl/length of operculum 0.06. Nucleus large, 0.32–0.37 length of operculum, central. Inner surface with slightly raised spiral ridge surrounding nucleus. Exterior with overlapping edges of each whorl; otherwise smooth (examined from 3 specimens from type locality and AMS C202187).

Radula (Fig. 20G,H) of 17 rows (from one specimen only). Central teeth with 2–3 sharp, approximately equal-sized lateral cusps above one large cusp (2–3x length of cusp above) at lower ⅓ with 1–2 cusps below; upper most of basal cusps sometimes large, rarely as large as major cusp above it. All cusps occupy about ⅔ length of mesocone. Base about 1.58 wider than long, about 1.67 wider than width of mesocone, outer edges lightly convex, dorsal basal thickening prominent, anterior articulatory thickening thrust forwards, abutting strongly concave posterior articulatory thickening that lies beneath mesocone of next tooth. Width of lateral elements about half length, straight laterally, with slightly thickened inner ends; narrow spaces between each element (examined from 1 specimen, AMS C364664 and 1 from type locality).

Distribution (Fig. 17). Western Tasmania.

Remarks. The specimen illustrated in Fig. 22B shows slight hyperstrophic coiling but other specimens are planispiral or nearly planispiral (e.g., Fig. 22E).

Table 22. Shell measurements of the types of *T. punctatus*.

dmin	dmax	mdht	mxht	aph	apw	whl
holotype						
1.45	1.72	0.40	0.60	0.60	0.54	2.00
paratypes (AMS C202187)						
1.67	1.99	0.43	0.66	0.65	0.59	2.10
1.48	1.74	0.37	0.59	0.57	0.52	2.20
1.26	1.52	0.36	0.55	0.54	0.54	2.00
1.09	1.34	0.30	0.49	0.44	0.48	1.95
1.17	1.42	0.33	0.54	0.54	0.48	1.85
1.24	1.53	0.34	0.58	0.57	0.52	1.90
1.83	2.09	0.50	0.65	0.64	0.62	2.45

Gondwanorbis Ponder, 1986

Type species. *Glacidorbis magallanicus* Meier-Brook & Smith, 1976, Chile.

Originally proposed as a subgenus, *Gondwanorbis* was raised to generic rank by Starobogatov (1988). Diagnostic characters that were originally given were the peripheral keel on the shell and the base of central radular teeth being about twice as wide as the mesocone and the radula with or without a pair of vestigial lateral teeth. To this can be added the circular, paucispiral operculum with a central nucleus (Meier-Brook & Smith, 1976, fig. 3), a character shared with *Striadorbis*, although it is not known if the South American taxon has external pustules on the operculum. The articulation of the teeth appears to be similar to that seen in *Glacidorbis* (Meier-Brook & Smith, 1976, fig. 4).

Discussion

Relationships within the family. Bunn & Stoddart (1983) used a Wagner network in an attempt to indicate "relationships" of the five living species included in *Glacidorbis* at the time. Their diagram shows *G. occidentalis* and *"G." pedderi* as sister taxa, *G. hedleyi* and *"G." magallanicus* as sisters and *"G." pawpela* as well removed from the other taxa. The data used in their phenetic analysis consisted of six characters, two shell characters (maximum diameter and presence of keel) and four radular characters (average teeth rows, average cusps per side, presence of marginal teeth, and tooth height/depth at base).

A cladistic analysis of relationships using parsimony methods is given below. The lack of anatomical data for all but two taxa necessitates an analysis using only radular, shell and opercular characters. The characters and their states used are as follows:

Shell characters

1 Dorsal keel. 0—absent, 1—present.
2 Strength of dorsal keel. 0—weak angulation, 1—moderate, 2—strong, dash—inapplicable.
3 Ventral keel or angulation in middle to inner quarter of base. 0—absent, 1—present.
4 Peripheral keel. 0—absent, 1—present (autapomorphy of *Gondwanorbis*).
5 Development of ventral keel or angulation in middle to inner quarter of base. 0—only weak angulation or ridge, 1—strong keel, dash—inapplicable.
6 Position of dorsal keel or angulation. 0—in middle of whorl, 1—in inner third to quarter, dash—inapplicable.
7 Position of ventral keel or angulation. 0—in middle of whorl, 1—in inner third to quarter, dash—inapplicable.
8 Keel or ridge in outer ⅓ of base. 0—absent, 1—present (autapomorphy of *B. fultoni*).
9 Spiral threads or cords on dorsal (and ventral) surface. 0—absent, 1—present.
10 Strength of spirals. 0—subobsolete, 1—weak to moderate threads, 2—strong cords, dash—inapplicable.
11 Spiral threads or cords on periphery. 0—absent, 1—present.
12 Axial costate present. 0—absent, 1—present.
13 Distribution of axial costae. 0—confined to early teleoconch whorls, 1—over whole shell surface, dash—inapplicable.
14 Coiling pattern. 0—orthostrophic, 1—planispiral, 2—hyperstrophic.
15 Protoconch apical sculpture. 0—granules, 1—punctures, 2—spiral and axial threads.
16 Secondary protoconch sculpture. 0—smooth except for axial threads, 1—with spirals.
17 Shell punctures. 0—absent, 1—present (autapomorphy of *Tasmodorbis*).
18 Growth lines. 0—orthocline, 1—prosocline.

Opercular characters

19 Opercular shape. 0—oval, nucleus eccentric to subcentral; 1—circular with central nucleus.
20 Number of opercular spirals. 0—few (less than 4), 1—4 or more.
21 Opercular sculpture on outer surface. 0—smooth, 1—with granules.
22 Opercular whorl overlap. 0—little or no overlap, 1—whorls overlapping.

Radular characters

23 Radular base. 0—expanded acutely beyond mesocone; 1—not acutely expanded, approximately triangular in outline.
24 Cusp pattern. 0—even, 1—one cusp much larger (autapomorphy of *Tasmodorbis*).
25 Articulation of teeth. 0—anterior stronger, or subequal to posterior; 1—posterior stronger.

Table 23. The data matrix used in the cladistic analysis. The character numbers correspond to those listed in the text. Dash = inapplicable, ? = unknown.

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Gondwanorbis	0	–	0	1	0	–	–	0	0	–	0	0	–	1	?	?	?	0	1	1	?	0	?	0	0
Glacidorbis hedleyi	0/1	0	0	0	0	–	–	0	0	–	0	0	–	0	0	0	0	0	0	0	1	0	0	0	0
Glacidorbis catomus	1	1	1	0	0/1	0/1	0	0	0	–	0	0	–	0	1	0	0	0	0	0	1	0	0	0	0
Glacidorbis bicarinatus	1	2	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0
Glacidorbis atrophus	1	2	1	0	0	0	1	0	0	–	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0
Glacidorbis decoratus	1	2	1	0	0	1	1	0	0	–	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0
Glacidorbis otwayensis	1	0/1	1	0	0	0	1	0	0	–	0	0	–	0	1	0	0	0	?	?	?	?	?	?	?
Glacidorbis rusticus	1	2	1	0	0	1	1	0	0	–	0	0	–	0	1	0	0	0	0	0	1	0	0	0	0
Glacidorbis tasmanicus	0/1	0	0	0	–	–	–	0	0	–	0	0	–	0	1	0	0	0	0	0	1	0	0	0	0
Glacidorbis costatus	0	–	0	0	–	–	–	0	0	–	0	1	1	0	1	0	0	0	?	?	?	?	?	?	?
Glacidorbis occidentalis	0	–	0	0	–	–	–	0	0	–	0	0	–	0	1	0	0	0	0	0	1	0	0	0	0
Glacidorbis troglodytes	0	–	0	0	–	–	–	0	0	–	0/1	0	–	0/2	1	0	0	0	?	?	?	?	?	?	?
Glacidorbis circulus	1	1	1	0	1	0	1	0	1	2	0	0	–	0	1	0	0	0	0	0	1	?	?	?	?
Glacidorbis isolatus	1	2	1	0	1	1	0	0	0	–	0	0	–	0	0	0	0	0	0	0	1	?	0	?	?
Striadorbis pedderi	1	2	1	0	0	0/1	0	0	1	1	1	0	–	1	0	1	0	0	1	1	1	0	0	0	1
Striadorbis spiralis	0	–	0	0	–	0	–	0	1	2	0	0	–	1	0	1	0	0	1	1	1	0	0	0	1
Striadorbis janetae	1	1	1	0	0	0	0	0	1	2	0	0	–	1	?	1	0	0	1	?	1	?	?	?	?
Benthodorbis pawpela	0	–	0	0	–	–	–	0	1	1	1	0	–	2	0	1	0	1	0	0	?	1	1	0	0
Benthodorbis fultoni	0	–	0	0	–	–	–	0/1	1	1	1	0	–	2	0	1	0	1	0	0	0	1	?	0	0
Tasmodorbis punctatus	0	–	0	0	–	–	–	0	0	0	0	0	–	1/2	0	1	1	0	1	1	0	1	1	1	0

The data matrix used is given in Table 23. This was analysed using using the default heuristic search options in PAUP* and 10 random iterations.

In the analysis (all characters unordered and unweighted) 7236 equally parsimonious trees were generated [length 45, Consistency Index (CI) 0.60, Homoplasy Index (HI) 0.40, Retention Index (RI) 0.75, Rescaled Consistency Index (RC) 0.45]. Despite the large number of trees, the resulting strict consensus tree supported the generic groupings (Fig. 23). The tree consists of three clades—one being *Striadorbis* with *S. spiralis* basal, the second comprising *Benthodorbis* and *Tasmodorbis*, and the third *Glacidorbis* (Bremer support values are given in Fig. 23). *Striadorbis* is supported by four characters, dorsal shell keels (2), spiral sculpture on the teleoconch (9, 10), and the third the articulation of the radula (25). The *Benthodorbis* + *Tasmodorbis* clade is supported by four supposedly synapomorphic character states that are shown as reversals in the analysis but are probably all plesiomorphic: 14,1 (planispiral coiling pattern—the condition in the outgroup), 21 (lack of opercular sculpture—condition not known in outgroup but absent in other operculate heterobranchs so presumably actually plesiomorphic), 22,1 (opercular whorl overlap—condition in outgroup unknown but this is probably the plesiomorphic condition in other gastropods) and 23,1 (radular base not expanded—although the outgroup has a widely expanded base, this is not the case with most other heterobranch groups).

Two autapomorphies support *Tasmodorbis* (17,1—shell punctures and 24,1—uneven radular cusp pattern). *Benthodorbis* is supported by one autapomorphy (18,1—prosocline growth lines) and five homoplastic apomorphies related to spiral sculpture on the teleoconch (9,1, 10,1 and 11,1) and the operculum (19,0 and 20,0).

Glacidorbis is supported by two synapomorphic character states (14,0—orthostrophic shell shape and 16,1—smooth secondary protoconch). The available data are not sufficiently robust to allow an assessment of the relationships within *Glacidorbis*, the only clade being supported in the strict consensus tree consisting of species similar to *G. bicarinatus*, together with *G. isolatus* and *G. circulus*. This node is supported by three homoplastic shell characters (1, 2, 5) all related to dorsal and ventral keels. While the dorsal and ventral keels co-occur in nearly all keeled taxa within *Glacidorbis*, the degree of their development is not entirely correlated, nor is their location on the shell. It is for this reason that six characters involving dorsal and ventral keels were scored. However, this has resulted in these largely correlated characters dominating the analysis. *Glacidorbis isolatus* is, for example, grouped with the other keeled species but this species shares granulate protoconch microsculpture with *G. hedleyi*, and these are the only taxa occurring in New South Wales, the remaining taxa having punctate protoconch sculpture.

The analyses are limited in that no anatomical characters could be used because of lack of data and because of the lack of information in some key characters concerning the outgroup. While the results support the monophyly of the generic groupings used, the sister group relationship identified for *Tasmodorbis* and *Benthodorbis* may not be supported once additional data are available.

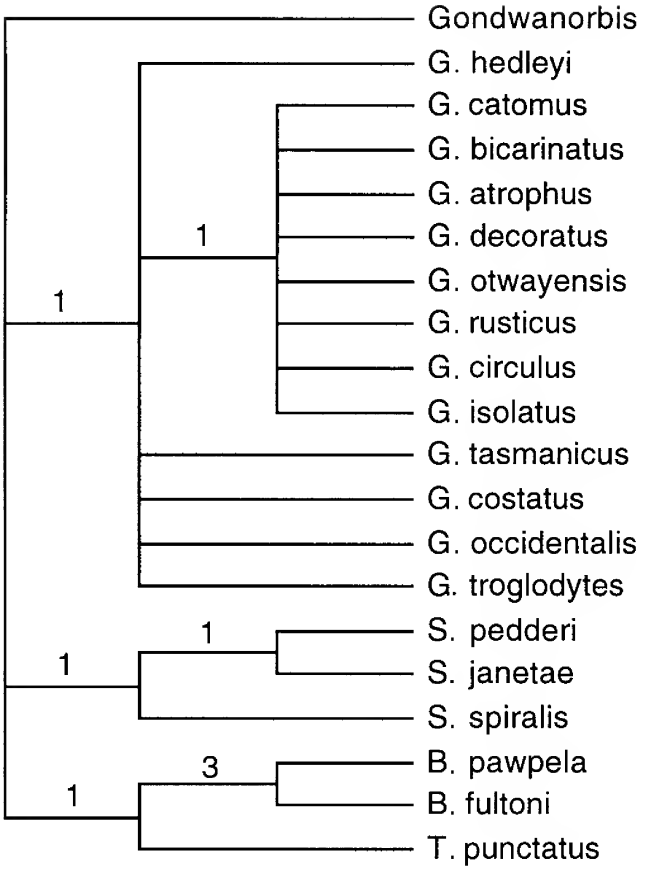

Figure 23. Strict consensus of the shortest trees produced from the data in Table 23. All characters are unordered and unweighted. The level of Bremer support is indicated at each node.

Biogeography. The biogeography of this group, based on the small number of taxa previously known, has been briefly discussed by Meier-Brook & Smith (1976) and Bănărescu (1990). The majority of species occur in northern and western Tasmania, with a few taxa in Victoria, eastern-most South Australia and New South Wales. In general, the distribution of glacidorbids in Tasmania shows a somewhat similar pattern to hydrobiid gastropods of the *Beddomeia* group (Ponder *et al.*, 1993). Species of *Glacidorbis* occur across the northern third of the island while *Tasmodorbis* is restricted to the western part of Tasmania. *Striadorbis pedderi* is also found in the western part of Tasmania but extends further to the east than *Tasmodorbis*. The other Tasmanian species of *Striadorbis* is found on the northern half of the east coast, the remaining species being found in western Victoria. With the exception of this latter species, the other glacidorbids found on the mainland are species of *Glacidorbis*. They are found in swamps and streams along the Great Divide and in nearby high country in New South Wales and Victoria (*G. hedleyi, G. isolatus*), or in coastal drainages in Victoria or just across the border in South Australia (*G. troglodytes, G. rusticus, G. otwayensis*) and in south Western Australia (*G. occidentalis*). *Benthodorbis* is restricted to two of the older lakes in Tasmania, this

apparent genus-level endemism in these lakes not being reflected in hydrobiids. While the above distribution patterns are unlikely to change substantially, these tiny animals are easily missed and additional collecting will probably change the detail. The lack of glacidorbids from mainland inland, northern and north eastern drainages is probably real, given the extensive collecting in these areas for small freshwater molluscs in recent years.

Species occupy wider ranges than seen in many hydrobiids (Ponder, 1994 and references therein). Nevertheless, a few species appear to be restricted in range (see Conservation below). There are few records of glacidorbids occurring in sympatry and, when they do, the taxa are not congeneric.

Ecology and biology. Relatively few observations have been made on the ecology of species of glacidorbids but the species clearly occupy a wide range of habitats from swamps and bogs to streams and rivers. They are normally found on macrophytes and other vegetation such as moss or roots, on pieces of wood, or, more rarely, under stones. The two species of *Benthodorbis* live on sediment on the bottom of lakes. Some, such as *G. hedleyi,* are tolerant of a wide range of temperature, conductivity, dissolved oxygen and pH (Boulton & Smith, 1985: pH values ranging from 4.8–7.6, temperature from 2–21°C, dissolved oxygen 1.2–15.0 ppm and conductivity 48–225 µS/cm). Bunn & Stoddart (1983) give a range of pH 6.3–6.4 for *G. occidentalis*.

An analysis of the 112 records of pH for glacidorbids in the Australian Museum collections shows a range from 4.85 to 8.00 (mean 6.392) and for conductivity a range of 0.01–1.93 (mean 0.264, n = 108) (see Table 24 for species level summary).

Glacidorbis occidentalis lives in intermittent streams (Bunn *et al.*, 1989) and *G. hedleyi* is also known to occur in intermittent habitats (Boulton & Smith, 1985) but most of the other species appear to live in permanent to semi-permanent streams and swamps.

Glacidorbis hedleyi was shown to be a carnivore (Ponder, 1986) but no observations on the food or feeding of other species have been made. The occurrence of large numbers of *Pinus* pollen grains in the digestive gland of *G. occidentalis* suggests the interesting possibility that this species may be feeding, at least in part, on pollen.

To date, only two species have been definitely confirmed as brooding young; *Glacidorbis hedleyi* and *Benthodorbis pawpela*. In this study each species has not been examined systematically, mainly because available material is limited. The unusual reproductive mode seen in *G. hedleyi* (Ponder, 1986), in which protandric males have to copulate before turning into females, warrants comparative investigation of other taxa.

Conservation. The conservation of small, narrow-range freshwater molluscs in Australia has been highlighted by Ponder (1994). Some species of *Glacidorbis* have restricted ranges, and one (*G. costatus*) appears to be extinct, probably as a result of the draining of Pulbeena Swamp for farming and mining. *Glacidorbis troglodytes* and *G. spiralis* are also only known from single locations but may be found to have, at least, slightly wider distributions. In the case of *G. troglodytes*, other sink holes in the Mt Gambier area have not been adequately examined and *G. spiralis* undoubtedly has a more extensive distribution within the Franklin River than the available sampling indicates. *Glacidorbis circulus* is known from only two locations on Marine Creek on the mid north coast of Tasmania. The only other taxa restricted to single locations are the species of *Benthodorbis*, both found in single lakes (Great Lake and Lake Sorell). Both these species are found on soft sediment on the lake bottom and could be susceptible to damage from introduced carp (*Cyprinus carpio* L.). All other taxa are more widely distributed, with the most widespread taxon being *G. hedleyi*.

Table 24. Summary of pH and conductivity records in the Australian Museum collections for glacidorbid taxa. The range (mean) and ± standard deviation are given. Each record represents a single reading.

taxon	n	pH	n	conductivity
Glacidorbis	95	4.85–7.65 (6.343)±0.526	94	0.01–0.84 (0.210)±0.203
Glacidorbis atrophus	6	6.07–6.59 (6.208)±0.224	6	0.05–0.14 (0.113)±0.042
Glacidorbis bicarinatus	8	6.00–6.42 (6.262)±0.181	7	0.06–0.10 (0.067)±0.015
Glacidorbis catomus	10	5.62–7.65 (6.552)±0.577	13	0.07–0.79 (0.225)±0.190
Glacidorbis circulus	3	6.50–7.58 (6.860)±0.624	3	0.09
Glacidorbis decoratus	14	5.60–6.68 (6.036)±0.273	10	0.50–0.21 (0.103)±0.052
Glacidorbis hedleyi	14	6.10–7.34 (6.673)±0.395	14	0.02–0.14 (0.058)±0.040
Glacidorbis otwayensis	2	6.20–6.65 (6.425)±0.318	2	0.10
Glacidorbis rusticus	27	5.30–7.46 (6.120)±0.510	28	0.20–0.84 (0.444)±0.180
Glacidorbis tasmanicus	11	4.85–7.26 (6.645)±0.725	11	0.01–0.22 (0.082)±0.069
Striadorbis	15	5.50–8.00 (6.682)±0.844	9	0.01–1.93 (0.716)±0.899
Striadorbis janetae	2	6.00–6.75 (6.375)±0.530	1	0.18
Striadorbis pedderi	12	5.50–8.00 (6.390)±0.762	7	0.01–0.23 (0.099)±0.078
Striadorbis spiralis	1	7.71	1	1.93
Tasmodorbis	2	6.21–6.47 (6.34)±0.184	2	0.07–0.08 (0.075)±0.007

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References

Bănărescu, P., 1990. *Zoogeography of Fresh Waters. Vol. 1. General distribution and dispersal of freshwater animals*. Wiesbaden: AULA-Verlag.

Boulton, A., & B.J. Smith, 1985. A range extension of the snail *Glacidorbis hedleyi* Iredale, 1943 in Victoria. *Victorian Naturalist* 103(4): 123–126.

Bunn, S.E., P.M. Davies & P.H. Edward, 1989. The association of *Glacidorbis occidentalis* Bunn and Stoddard, 1983 with intermittently-flowing, forest streams in south Western Australia. *Journal of the Malacological Society of Australia* 10: 25–34.

Bunn, S.E., & J.A. Stoddart, 1983. A new species of the prosobranch gastropod *Glacidorbis* and its implications for the biogeography of south-western Australia. *Records of the Western Australian Museum* 11(1): 49–57.

Buonaiuto, M.F., 1982. *Late Cainozoic Non-Marine Mollusca of the Lake Frome Area and Other Selected Localities in Northern South Australia*. South Australia Department of Mines and Energy. Unpublished report, Biostratigraphy, no. 12/81, DMF no. 469/76.

Colhoun, E.A., G. van de Geer & W.G. Mook, 1982. Stratigraphy, pollen analysis, and palaeoclimatic interpretation of Pulbeena Swamp, northwestern Tasmania. *Quaternary Research* 18: 108–126.

De Deckker, P., 1982. Non-marine ostracods from two Quaternary profiles at Pulbeena and Mowbray Swamps, Tasmania. *Alcheringa* 6: 249–274.

Fulton, W., 1983. Macrobenthic fauna of Great Lake, Arthurs Lake and Lake Sorell, Tasmania. *Australian Journal of Marine and Freshwater Research* 34: 775–785.

Haszprunar, G., 1985. The fine morphology of the osphradial sense organs of the Mollusca. Part 2: Allogastropoda (Architectonicidae and Pyramidellidae). *Philosophical Transactions of the Royal Society of London* B 307: 497–505.

Haszprunar, G., 1988. On the origin and evolution of major gastropod groups, with special reference to the Streptoneura (Mollusca). *Journal of Molluscan Studies* 54: 367–441.

Haszprunar, G., & G. Huber, 1990. On the central nervous system of Smeagolidae and Rhodopidae, two families questionably allied to the Gymnomorpha (Gastropoda: Euthyneura). *Journal of Zoology* (London) 220: 185–199.

Huber, G., 1993. On the central nervous system of marine Heterobranchia (Gastropoda). *Journal of Molluscan Studies* 59: 381–420.

Iredale, T., 1943. A basic list of the freshwater Mollusca of Australia. *Australian Zoologist* 10(2): 188–230.

Meier-Brook, C., & B.J. Smith, 1976. *Glacidorbis* Iredale 1943, a genus of freshwater prosobranchs with a Tasmanian-Southeast Australian-South Andean distribution. *Archiv für Molluskenkunde* 106: 191–198.

Ponder, W.F., 1986. Glacidorbidae (Glacidorbiacea: Basommatophora), a new family and superfamily of operculate freshwater gastropods. *Journal of the Linnean Society of London* 87: 53–83.

Ponder, W.F., 1991. Australian Hydrobiidae—an overview based on current research. *Proceedings of the 10th International Malacological Congress, Tübingen, 1989*: 525–528.

Ponder, W.F., 1994. Australian freshwater Mollusca: Conservation priorities and indicator species. *Memoirs of the Queensland Museum* 36: 191–196.

Ponder, W.F., 1996. Freshwater molluscs of northeast Tasmania. In *Biogeography of Northeast Tasmania*, ed. R. Mesibov. *Records of the Queen Victoria Museum and Art Gallery* 103: 185–191.

Ponder, W.F., G.A. Clark, A. Miller & A. Toluzzi, 1993. On a major radiation of freshwater snails in Tasmania and eastern Victoria—a preliminary overview of the *Beddomeia* group (Mollusca: Gastropoda: Hydrobiidae). *Invertebrate Taxonomy* 7: 501–750.

Ponder, W.F., & R.G. de Keyzer, 1998. Superfamily Rissooidea. In *Mollusca: The Southern Synthesis. Fauna of Australia, vol. 5, part B*, ed. P.L. Beesley, G.J.B. Ross & A. Wells, pp. 745–766. Melbourne: CSIRO Publishing.

Ponder, W.F., & D.R. Lindberg, 1997. Towards a phylogeny of gastropod molluscs—a preliminary analysis using morphological characters. *Zoological Journal of the Linnean Society* 19(2): 83–265.

Ponder, W.F., & A. Warén, 1988. Classification of the Caenogastropoda and Heterostropha—a list of the family- group names and higher taxa. In *Prosobranch phylogeny*, ed. W.F. Ponder, pp. 288–328. *Malacological Review, Supplement* 4.

Reindl, S., & G. Haszprunar, 1994. Light and electron microscopical investigations on shell pores (caeca) of fissurellid limpets (Mollusca: Archaeogastropoda). *Journal of Zoology* (London) 233: 385–404.

Smith, B.J., 1973. A new species of snail from Lake Pedder, Tasmania, possibly belonging to the family Valvatidae. *Journal of the Malacological Society of Australia* 2(4): 429–434.

Smith, B.J., 1978. Notes on the molluscs of the Victorian Great Dividing Range. *Victorian Naturalist* 95(6): 236–240.

Smith, B.J., 1979. A new species of the genus *Glacidorbis* (?Hydrobiidae: Gastropoda) from Great Lake, Tasmania. *Journal of the Malacological Society of Australia* 4(3): 121–127.

Smith, B.J., 1992. *Zoological Catalogue of Australia: Non-Marine Mollusca*. Canberra: Australian Government Publishing Service.

Smith, B.J., & R.C. Kershaw, 1979. *Field Guide to the Non-Marine Molluscs of South Eastern Australia*. Canberra: Australian National University Press.

Smith, B.J., & R.C. Kershaw, 1981. *Tasmanian Land and Freshwater Molluscs*. Fauna of Tasmania Handbook 5.

Sorenson, M.D., 1999. *TreeRot, version 2*. Boston: Boston University.

Stanisic, J., 1998. Superfamily Glacidorboidea. In *Mollusca: The Southern Synthesis. Fauna of Australia, vol. 5, part B*, ed. P.L. Beesley, G.J.B. Ross & A. Wells, pp. 1075–1076. Melbourne: CSIRO Publishing.

Starobogatov, Y.I., 1988. On the systematic position of the genus *Glacidorbis* (Gastropoda incertae sedis). *Proceedings of the Zoological Institute, Leningrad* 176: 78–84 [in Russian].

Swofford, D.L., 1999. *PAUP*, Phylogenetic Analysis Using Parsimony (and Other Methods)*. Sunderland, Massachusetts: Sinauer Associates.

Visser, M.H.C., 1988. The significance of terminal duct structures and the role of neoteny in the evolution of the reproductive system of Pulmonata. *Zoologica Scripta* 17(3): 239–252.

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Taxonomic index

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